POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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"They Also Serve—"

THE GREAT WORKS of man are built not only by those whose names adorn the marble facades of public buildings; not alone by those to whom bronze tablets are erected. Such names, often, are but symbols of man's vanity, characters which reveal his futile yearning for immortality.

Even where the placing of such names is justified, the achievements which they commemorate are rarely those which they have brought about alone. There may be a few exceptions, but, in general, all great achievements involve the coördinated effort and enterprise of large numbers of individuals—people whose names never find their way into imperishable bronze or granite, but whose share in the work, nevertheless, has been vital. Their parts may have been small but each in his turn contributed his bit to the success and grandeur of the finished structure. It is so with ships and bridges and buildings and railroads; it is so with nations and empires.

In the installation of the great 183,000 kv-a. electric generator at Richmond Station, recently, the chief designers may be proud, and justly so, of their splendid accomplishment. But in giving credit, and there is ample to go around, let us not forget those who, each in their turn, contributed their small but necessary part in making this symphony in steel and copper and insulation a success. For, "they also" served and what is more, they served well.

The caption to the photograph shown above when it was submitted to us with the article on page 508, read simply: "One of the stator coils for the Richmond generator." The coil is interesting, of course, particularly in view of its magnitude, but somehow as we looked at the picture we were more interested in the three figures behind whom we suspect did such a beautiful job of wrapping the coil. A mere detail in the construction of the machine, perhaps, but a highly important one, involving many hours of close application, skill and manual dexterity. These workers, perhaps, do not understand the meaning of such terms as synchronous reactance, but they do know how to wrap stator coils, and, that is all that is required of them. That is how they serve.

Our thoughts on this subject carry us a step further, beyond the human to some of the inanimate elements of the power plant structure. The poet, in writing the lines, intended no such implication, perhaps, but as we read the article on the Charging of Storage Batteries on page .. it seemed to us that here was rather a remarkable piece of equipment which usually "stands and waits" but when it serves, serves well. Always ready for instant action, capable of enormous overloads in case of emergency, independent of all other sources of power, the storage battery whether in a power plant or in an automobile is a highly necessary and valuable device but one which usually receives only slight recognition.

Much has been written about the storage battery but we cannot remember ever having read such a concise yet detailed treatment of the factors involved in charging batteries as that presented in this issue by J. Lester Woodbridge. The article is an abstract of a paper which Mr. Woodbridge presented at the Summer Convention of the American Institute of Electrical Engineers at Ithica, but we have tried not to eliminate any of the essential details in our abstract. This article, in our opinion, deserves the earnest consideration of everybody concerned with the use and care of storage batteries, whether a simple automobile battery or a central station emergency storage battery power supply.

With the Editors

Human Catalysis

NOBODY WHO LISTENS to the national radio programs with any degree of regularity can fail to have been impressed by the outstanding merit and success of Major Bowes' Amateur Hour on Sunday evenings. Here men and women, boys and girls—people from all walks of life and from all strata of society who feel that they possess histrionic talent are given the opportunity to appear before the microphone and submit their wares to the judgment of the millions of listeners throughout the nation. Those who win each Sunday evening are given immediate professional engagements. It is a program filled with deep human interest, with romance—where obscure souls with talent and artistic ability who never had a chance and who never would have a chance, are suddenly elevated to recognition and fame and success.

Now, amateur hours or nights are nothing new. The old Bowery theaters had their amateur nights and on the radio there have been amateur hours for years. But this amateur hour of Major Bowes' somehow is different. It accomplishes something, it has a purpose —that of providing opportunity for those who otherwise would never have it. Heretofore amateur hours have meant merely the removal of restriction on good behavior and an indulgence, more or less, in rowdyism.

What is the reason for this difference between this and other amateur hours? The reason is *Major Bowes* —the man, his charming personality, his gracious and dignified manner, his astonishing knowledge and understanding of personalities. Because of him, these unknown amateurs are brought into intimate relationship with the public and if they "click" the inevitable reaction takes place. Success is theirs.

Major Bowes is what, in chemistry, is known as a catalyst. The process of catalysis is known to every highschool boy, but ordinarily we do not use the term except to explain the occasional reactions of platinum sponge, precipitated nickel, etc. But catalysis applies equally well to human relations, in fact, human catalysts abound everywhere.

Imagine a group of men—business men, engineers, anything. They are confronted with serious problems —it is a rainy day. Gloom prevails—nothing gets done. Then somebody walks in and wants to know if he may sit down, tells a story, and in a few minutes the entire mental atmosphere is changed. The cloud of gloom is dispelled and the group begins to coöperate, action is taken and everybody is happy.

The man who came in last was a catalyst. He had nothing to do with the problems at hand but somehow he brought about the reaction which was necessary for their solution. In the end, he went his way, unchanged, capable of performing similarly in other groups.

It seems to us this business of human catalysts is rather important and while we cannot make ourselves human catalysts, we can keep our eyes open and recognize those that are and give them the opportunity to function. As engineers, we are continually confronted with the problem of getting somebody to appropriate money or time or material for things that we know should be done. Here, if we possess something of the power of a catalyst, we are fortunate but only few of us are endowed that way. So we must look for other catalysts to bring about the proper reaction.

There is an immense amount of rehabilitation work to be done in the power plants and industries of this country and there is plenty of capital available for doing it, but somehow the reaction we have all been looking and hoping for does not take place—not as rapidly, at least, as we should like to have it. Some say the Democrats are to blame, others say the Republicans, some blame the weather, it doesn't matter. Something is lacking. What we need is a Major Bowes—a supreme catalyst, somebody who can instil sufficient confidence in the future of industry and of the nation to bring about the reaction between work to be done and idle capital which we know is necessary.

Perhaps, however, it is too much to ask of any one person to act as a catalyst for the nation. There are many who think that our present President has this quality but there are others who have a different opinion. A president, it may be, is too vitally concerned in the reaction himself to be thought of in terms of a catalyst, indeed human catalysts more often are obscure figures who keep in the background.

In any event, there are many minor business-engineering reactions which can be brought about by minor catalysts and it is in this sense that we suggest a greater application to the study of human catalysis. In our own plants, in connection with our own problems, opportunity for human catalysts abound. As an engineer, you may know that it would be profitable to junk your old low pressure boilers and install a modern high pressure unit. The owner, however, does not know it, though he has money available for doing this work. You have tried to sell him the idea without much success. Though he has faith in you, he may not be confident of future conditions. What is necessary is a suitable catalyst—a human being perhaps or maybe an article in a magazine by a human being. For catalysts can act through the medium of the printed page. That's where we come in. In each number of this publication there are probably articles which can function to a certain extent as catalysts by virtue of the information they contain or the inspiration they hold. Such an article directed to the proper person or group of persons at the right time and under the proper circumstances sometimes can bring about an astonishingly quick reaction—just as a globule of mercury dropped into a solution can instantly bring about a violent chemical reaction. We cannot tell you exactly how to go about this since each particular case requires individual treatment but if this idea of human catalysts is kept in mind—well, at least it can do no harm.

High Capacity Pulverized Coal Boiler at the Southbridge Plant o

AMES WORSTED C

FOUNDED ONE HUNDRED AND eight years ago, the Ames Worsted Co. (until recently the Hamilton Woolen Co.)* at Southbridge, Massachusetts, has to its credit a record of continuous operation that can be equaled by few companies even in New England. Its plant at Southbridge—its mill buildings with its streams and "mill races" is as typically New England as baked beans on Saturday night and codfish balls on Sunday morning. Like many of its kind in New England, this plant is the product of time and mechanical development coupled with Yankee thrift and business acumen. As the business expanded, new buildings and additional equipment was added. Water power which was first used was later replaced by steam power. Steam engines gave way to steam turbines. Fire tube boilers were superceded by water tube boilers as the latter became available. Whenever engineering developments brought forth new equipment capable of more efficient operation, it was adopted. At the present time the mill is served by a modern power plant furnishing steam, water and electric power for all needs. The new boiler unit recently placed in operation has been operated at efficiencies as high as 81.5 per cent for furnace and boiler combined.

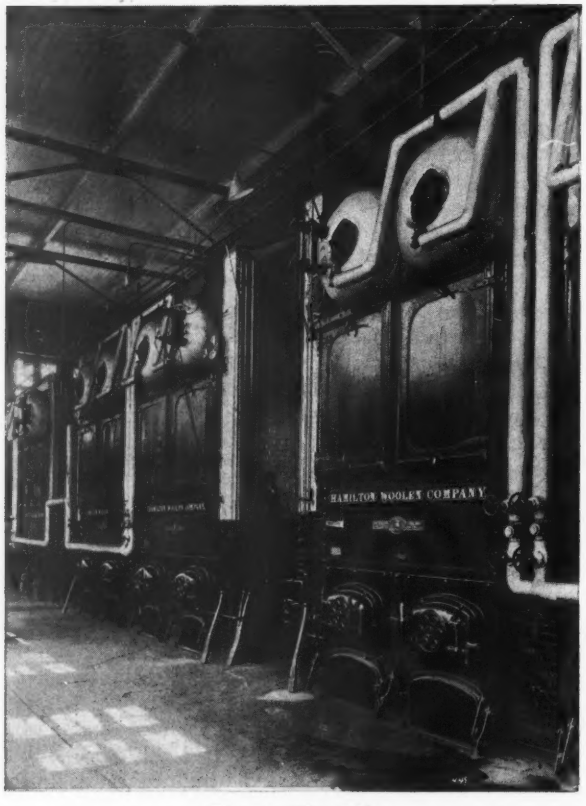

Fig. 1. The Old

This new boiler unit constitutes the latest addition to the power plant, but before we describe it in detail we will consider the general features of the plant, since it is in relation to such a plant as this that the unit is of particular interest. For at the present time this single new boiler is capable of carrying the entire load formerly supplied by eight old units. Two of these units were removed to make place for the new unit.

The plant consists of a two story brick building separate from the mill buildings proper. On one side, the turbine room occupies the second floor with the auxiliaries below on the first floor which is at ground level. On the other side, the boiler room occupies the full height of the building.

Until the new boiler unit was installed, all steam was furnished by eight longitudinal drum water tube boilers operating at 200 lb. pressure and fired manually. Ash was removed by hand and hauled away by means of industrial type cars operating on rails laid in the firing aisle.

The turbine room contains four turbo-generator units three of which operate condensing and the fourth non-condensing. All of these machines are General Electric Co. units and generate current at 2300 v. 60 cycle and operate on a steam pressure of 200 lbs. per sq. in. Two of the condensing units are rated at 500 kw. and the remaining one, which is an extraction type unit, at 1000 kw. The non-condensing unit also is a 1000-kw. machine.

*On April 15, 1935, The Hamilton Woolen Co. was taken over by the Ames Worsted Co. and the name changed accordingly.

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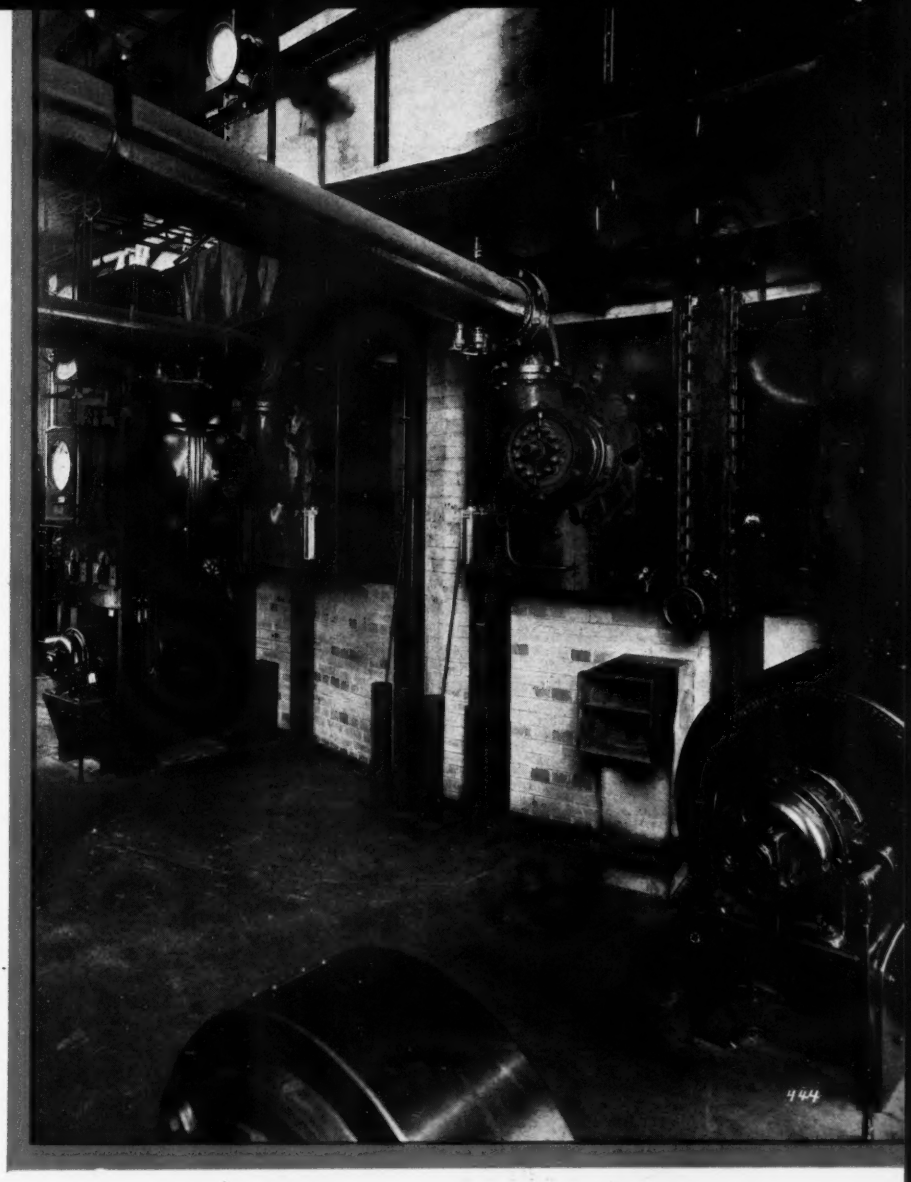


Fig. 2. The New

Excitation of all generators is supplied by separate exciters. One of these consists of a 200 amp., 125 v. direct current generator direct connected to a 3600 r.p.m., 150 lb. pressure General Electric Curtiss turbine, non-condensing. The other is an 1800 r.p.m. unit consisting of a 17½-kw., 125 v. direct current generator driven by a 60-hp., 2200 v. induction motor.

Distribution of current throughout the plant is at 2300 v. and is stepped down to lower voltages at the load centers. A twelve panel switchboard is installed in the turbine room, for control of the generator circuits and the feeder circuits. This board is an old one, made of marble and with manually operated oil circuit breakers mounted back of the panels. In addition to the electrical instruments on the switchboard, the plant is well equipped with recording instruments for measuring and recording steam and water flow and temperatures. Each turbine has its individual gage board with steam pressure and vacuum gages. Speed indicator and flow meters are installed on the main steam and hot water lines.

There are also installed in the turbine room, two rotary converters, rated at 300 kw., 600 v. d.c. These units are the property of the New England Power Co. and are used only to supply 600 v. direct current to the trolley used in handling coal outside the plant.

All turbine auxiliaries, including the feedwater heaters and feed pumps, are installed on the ground floor underneath the turbine room. For the condensing units, three Wheeler Condenser and Engineering Co. surface condensers are installed. Most of the auxiliaries are steam driven, the exhaust steam being used for feedwater heating and for heating water used in the dye house. For this purpose a large flash heater is provided. If there is not enough exhaust steam available for heating, extraction steam or exhaust steam from the non-condensing turbine is used.

Although the old boilers are still in good condition, about two years ago the management decided to improve the boiler plant by the installation of a modern pulverized coal fired boiler. The load at this plant, as is typical of many industrial loads, fluctuates considerably and a unit designed to meet these load fluctuations was desired. So two of the old boilers were removed and a new 70,000 lb. per hr. Riley steam generating unit was ordered and installed.

This unit was placed in operation just about a year ago and has given very satisfactory service. It consists of a 70,000 lb. per hr. Badenhausen boiler, built for a working pressure of 250 lb. in combination with two No. 3 Riley Atrita pulverizing mills and two No. 3 Riley burners. It is guaranteed to deliver 70,000 lb. of steam at 200 lb. pressure with feedwater at 210 deg. F. and a steam temperature of 407 deg. It has an operating ratio of 35 to 1.

The furnace is water cooled, having water walls with 854 sq. ft. of heating surface. The boiler proper has 6680 sq. ft. of heating surface, giving a total of 7534 sq. ft. in the boiler and furnace combined. The furnace is approximately 19 ft. deep by 14 ft. wide and 13 ft. high and has a volume of 3200 cu. ft.

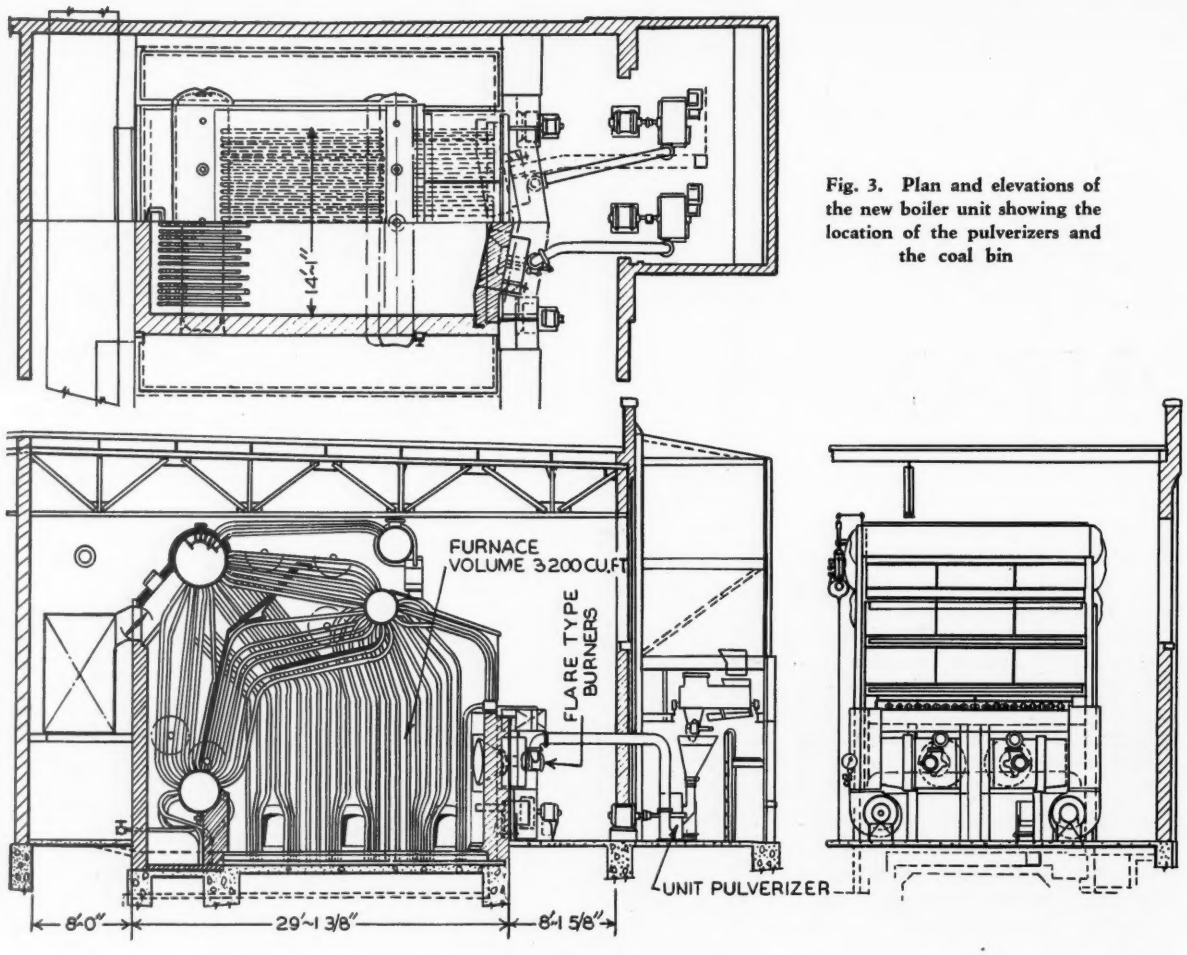


Fig. 3. Plan and elevations of the new boiler unit showing the location of the pulverizers and the coal bin

The arrangement of the equipment is shown in the plan and elevations in Fig. 3. The design of the boiler was determined to a large extent by the boiler house. It was necessary to install the boiler in the height beneath the roof trusses which is about 24 ft. By depressing the furnace floor some 22 inches below the boiler room floor level, however, it was accomplished without crowding as may be seen from the drawings and photographs.

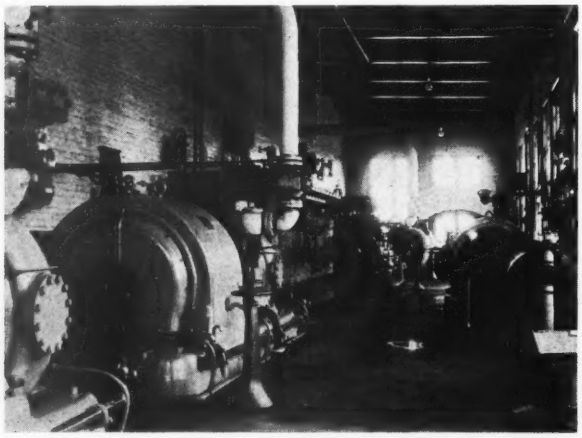


Fig. 4. The turbine room at the Ames Worsted Plant

In order to provide space for the pulverizers in front of the boiler, the boiler room was slightly extended at this point, as shown. A new coal bunker was also provided directly above this extension so that coal can be delivered directly to the pulverizers from the hopper above. This bunker has a flat bottom and is made of steel and provided with two discharge openings which deliver coal to two Richardson coal scales installed there. The scales feed into the pulverizer hoppers.

The coal used is Pocohontas, with a moisture content of 5 per cent and running 14,800 B.t.u. per lb. as fired and having an ash fusion temperature of 2500 deg. Primary air is heated in the front walls of the boiler and is carried to the pulverizers by a duct under the floor. The pulverizers are Riley Atrita units driven by 40 hp., 550 v., 3 phase 60 cycle General Electric Co. induction motors, controlled by G. E. starting compensators and switches.

Two forced draft fans are installed immediately in front of the boiler feeding directly to the burners. These are Buffalo, Type CL units, each driven by a 7½ hp., 550 v. General Electric induction motor. These fans draw heated air from the hollow furnace floor.

Control of this unit is centralized in a single control panel mounted at one side of the boiler. This panel contains a Bailey boiler meter, recording steam

flow and air flow, an Ellison multi-pointer draft gage and the necessary controls for the pulverizers and forced draft fans.

Boiler accessories include a Crosby illuminated steam pressure gage, Consolidated safety valves, Yarway blowoff valves, Reliance gage columns, Diamond soot blowers, and Swartwout feedwater control. The unit is served by the same stack that served the old boilers, a 175 ft. radial brick stack built by H. R. Heinicke, Inc. Hays inclined draft gages are provided for each pass in the boiler. Lunkenheimer valves are used throughout in the piping layout.

This unit as previously stated has operated very satisfactorily. Upon several occasions since it was placed in operation it has operated at a peak load of 73,000 lb. of steam per hour over short periods, using both burners and mills. It has also operated over week ends for periods of over twenty-four hours at a load of

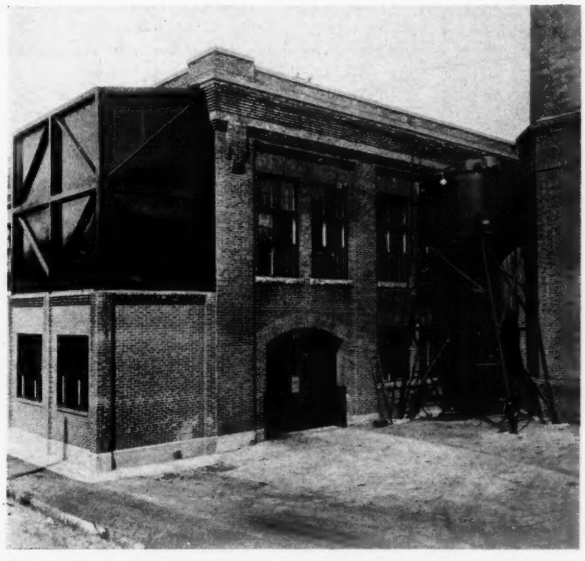


Fig. 5. View of part of the exterior of the plant showing the coal bunker mounted above the pulverizers

3000 lb. per hour using only one burner and mill. The ignition takes place practically at the burner and the flame varies in length before burning out. At a load of 3000 lb. of steam per hour, the visible flame from the burner tip appears to be only about three feet long.

The air supply is hand controlled but it has been handled very satisfactorily by the firemen who had no previous experience with pulverized fuel equipment. These firemen who formerly worked on hand fired boilers had no difficulty in learning to handle the new boiler and have operated the unit at an efficiency of around 80 per cent over a twenty-four hour period. Aside from its good efficiency the unit has proved very flexible in carrying various loads and in maintaining the steam pressure and a variation in load can be taken care of quickly when indicated by the boiler meter.

Under test conditions the efficiency of the boiler and furnace varied from 81.5 per cent when delivering 21,000 lb. of steam per hr., to 78.5 per cent when delivering 70,000 lb. of steam per hr. Considering the boiler alone, the delivery of 70,000 lb. of steam per hr. corresponds to operation at 320 per cent of the rated capacity.

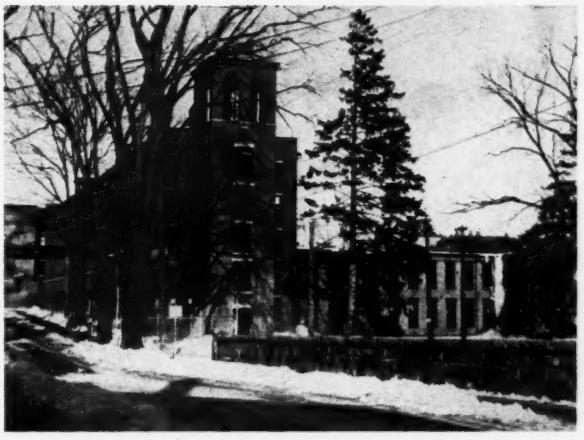


Fig. 6. "Its buildings are as typically 'New England' as baked beans on Saturday night"

The complete test data on these boilers is as follows:

1. Lb. steam per hr. act. evap.	20,000	35,000	50,000	70,000
2. Equiv. evap. F and A 212°	21,000	36,800	52,600	73,600
3. M. B.t.u. per hr. in steam above FW temp.	20,400	35,700	51,000	71,400
4. Developed boiler hp.	610	1072	1530	2144
5. Per cent rating, boiler alone	91	160	230	320
6. CO_2 in furnace	15	15	15	15
7. Mean furnace temp. deg. F.	....	....	2120	2250
8. CO_2 leaving boiler	14.5	14.5	14.5	14.0
9. Flue gas temp. boiler exit	450	497	546	590
10. Draft loss through boiler	0.1	0.26	0.56	0.9
11. Superheat leaving boiler deg. F.	4	6	8	10
12. Efficiency boiler and furnace	81.5	81.0	80.0	78.5
13. Lb. coal per hr.	1800	3150	4550	6500
14. Total air, lb. per hr.	23,800	41,600	60,000	86,000
15. Total S.P. at burners	0.2	0.9	0.4	0.9
16. No. of burners in use	1	1	2	2
17. Heat release B.t.u. per cu. ft. per hr. not incl. heater recovery	8300	14,400	20,600	28,400

From the above data, it is evident that this boiler unit is capable of handling wide variations in load and this has been substantiated by actual operating performance. Since it has been in operation it has carried the entire plant load and the old units are being used only as standbys.

We present this description as a good example of the type of improvement that is possible in many of the older plants using hand fired boilers. Especially where space is at a premium, modern, high capacity boiler equipment is extremely desirable.

In concluding this article we wish to express our appreciation to the management of the Ames Worsted Co. for courtesies extended in furnishing data regarding this new installation.

Governor Regulation *of* Steam Turbines

Part I. Determination of Governor Characteristics. Adjustments for Speed and Load Division Between Units. By William Welch, Jr., Assistant Mechanical Engineer, Interborough Rapid Transit Company, New York City

DISTURBANCES TO SYSTEM VOLTAGE, frequency, or load in steam-electric generating systems often can be traced to improper functioning of the turbine governors, in fact, the trouble, frequently, is caused by a mechanical defect in a particular governor. The remedy then is obvious and reliable operation can be restored easily. Sometimes disturbances occur even when inspections show that apparently the governors are all in excellent condition. When this is the case, very likely the trouble is due to misadjustment of the governors and reliable operation can then be achieved only after a thorough study of the problem.

A clear understanding of the function, construction, and operation of the usual speed-responsive turbine governor is essential in making a study of this kind and a brief description of the principles involved is necessary at this point. In systems of two or more turbine-driven a.c. generators operating in parallel the function of the turbine governor is two-fold; namely, (1) to divide system load changes between the machines according to some definite rule, and (2) to maintain system speed (frequency) within close limits. In practice the average output of the turbine is fixed by external adjustment to the governor by either manual or automatic control. The minute-to-minute changes in load, or swings, are carried by allowing the turbine speed to deviate slightly from normal, thus causing the governor to act to correct the load.

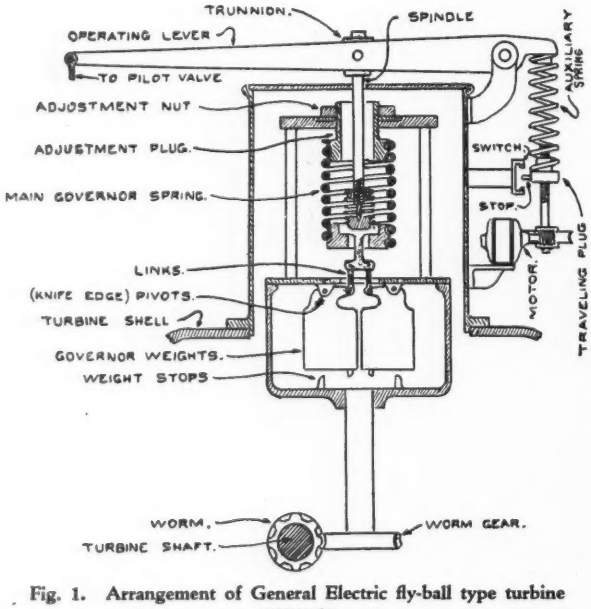


Fig. 1. Arrangement of General Electric fly-ball type turbine governor

Regulation

These two functions of the governor are dependent upon each other in that a governor can change turbine load only in response to a definite change in turbine speed. The change in speed required to produce a given change in load is known as the governor regulation. Regulation is fixed by the established characteristics of the governor which cannot be altered while the machine is in operation. A change in the average output of the turbine achieved through the external control will, however, change the effective regulation of the governor since the latter varies with the fixed output of the machine. The regulation, therefore, depends not only upon the characteristics of the various machines on a system, but also varies with the load upon each machine. For this reason the portions of the total load change carried by different machines on the line may vary considerably.

Division of Load

In a system supplied by a number of machines of different mechanical or electrical characteristics the manner in which load change is divided is of considerable importance. For instance, because of electrical characteristics it may be necessary to limit sudden increases in load on a particular generator in order to prevent temporary under-excitation with a consequent drop in voltage. Likewise, because of a lower heat rate, or some mechanical condition, it may be desirable to operate a certain unit at a fixed load and to allow other machines on the system to carry the swings in load. These conditions can be readily achieved through adjustment of the turbine governors to give the desired regulation. Except in a system supplied by a number of duplicate machines, the same regulation for all turbines is not always desirable.

The fly-ball governor is the type most commonly used for control of large steam turbines. In principle this mechanism is based upon the change in centrifugal

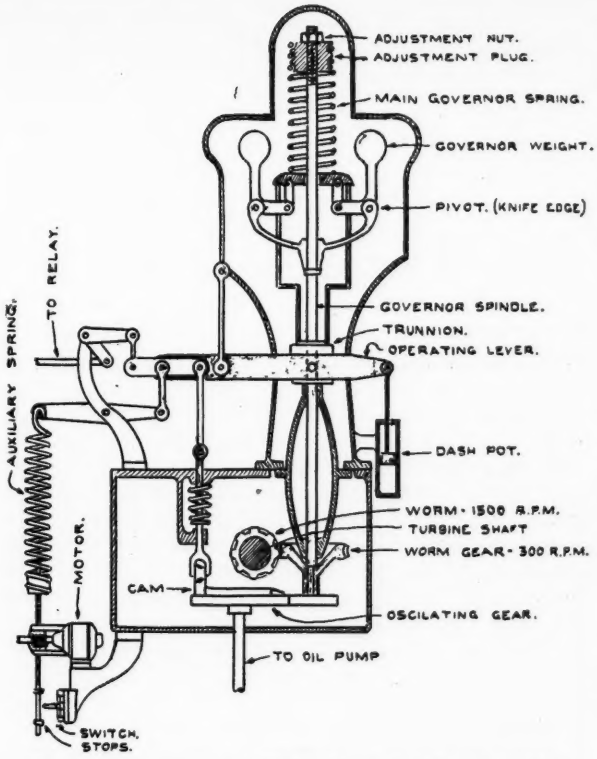


Fig. 2. Arrangement of Westinghouse fly-ball type turbine governor

force exerted by a system of revolving weights, the speed of which changes directly with changes in the turbine spindle speed. This type of governor as built by General Electric and Westinghouse is illustrated on Figs. 1 and 2. The governors are ruggedly built and in construction consist of a pair of weights attached to a vertical rotating shaft through a hinged joint. The motion of the weights is constrained to a radial arc about the hinge and is opposed by a coiled main spring. An increase in speed increases the centrifugal force exerted by the weights which then move up against the opposition of the main spring. Conversely with a drop in speed the weights move down.

Motion of the weights is transmitted by means of suitable linkage to the relay system controlling the position of the turbine steam admission valves. Thus, assuming no change in the governor spring, the position of the governor weights fixes the opening of the steam admission valve. Change in the valve opening naturally produces a change in the inlet steam pressure at the turbine head and as the change in load on a turbine is, roughly, proportional to inlet pressure the position of the governor weights, for fairly constant speed and steam conditions, establishes the turbine load. In other words, there is a fixed relation between the turbine speed and the turbine load.

Speed-Load Relation

If, however, the governor spring is changed, then the relationship between the turbine speed and the turbine load will be altered, but will be fixed for the new spring condition. Likewise, for any other spring condition there will be a different turbine speed-load relationship which will be fixed for that spring condition. This principle, then, permits holding constant speed on a turbine which has a variable output by changing the governor spring load with changes in turbine load. In the usual governor this result is accomplished by inserting a small auxiliary spring in the governor linkage system in series with the main governor spring. This auxiliary or "speed changer" spring is exterior to the governor and thus its load may be changed at will when the machine is operating, usually through a remote controlled electric motor.

Making Tests

In practice no attempt is made to maintain constant speed by changing the spring load to meet minor turbine load fluctuations, because of the impossibility of following rapidly changing load conditions in this manner but the speed is allowed to deviate slightly from the normal. These slight deviations in speed cause the governor, through the valve gear, to change the turbine load according to the speed-load rule established for the particular auxiliary spring load.

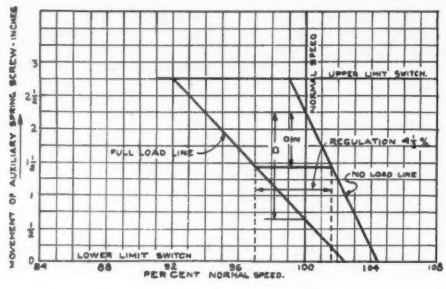
In discussing governor action the term "regulation" is used to describe the speed-load relationship. By definition turbine regulation is the change in turbine speed required to produce a given change in turbine load. As explained previously, the regulation varies with the effective load on the main governor spring which, of course, is affected by the load on the auxiliary spring so regulation is also a function of the auxiliary spring load. Frequently, nominal regulation is spoken of as that existing when the auxiliary spring is adjusted to normal speed at its ½-load position. This gives a convenient figure when expressed in percent of normal speed.

When the governor is set so that it is very active and the turbine responds rapidly to changes in speed, then the regulation is said to be "close", or "narrow". A close regulation results in the turbine actively correcting for every fluctuation in load with a minimum change in speed and voltage. If set too close, this condition may result in unstable operation.

On the other hand, when the governor is sluggish and the turbine holds near to a constant load, then the regulation is said to be "wide", or "broad". Wide regulation results in the turbine allowing fluctuations in load to be carried only by wide deviation in speed and voltage, or else by throwing the fluctuations to more active units. If carried to an extreme, this condition would result in excessive changes in frequency and voltage.

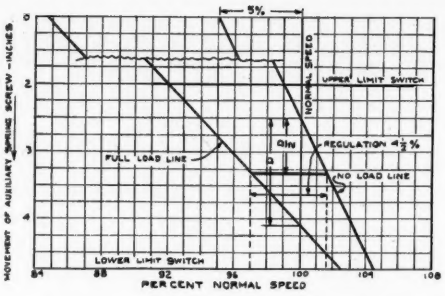
Governor Characteristics as Determined From Operating Data

When studying governor action of a number of machines in a system, complete characteristics of the governors are necessary. The data is obtained quite easily by the following method which can be adapted to any governor of this type. The method consists essentially of determining the relationship between turbine speed and length of the governor auxiliary spring at turbine friction load (no load) and full load. If desired, the data also can be obtained at several intermediate load points.



Figs. 3 and 4. Typical regulation curves for types of governors shown by Figs. 1 and 2. Fig. 3 (left). General Electric.

Fig. 4 (right). Westinghouse. Distance marked D is the travel of the adjusting screw to produce a given change in turbine load



The method as worked out consists of the following steps:

1. While the machine is still on the line and operating at normal speed, the position of the governor clutch is carefully measured at friction load, ¼, ½, ¾ and full load positions.

2. The machine is then taken off the line and run at reduced speed by regulating the throttle valve. The admission valves will then be full open. Full steam pressure and superheat at the throttle and full vacuum at the exhaust are maintained.

3. The length of the auxiliary spring is adjusted so that the no-load limit switch is just closed.

4. The turbine speed is then gradually increased by opening the throttle until the admission valve is just starting to close. As this represents the full-load condition, the exact speed is noted. In a similar manner the speed is increased further and noted at the predetermined points of ¾, ½, ¼, and no-load. The last point is reached when the admission valve is practically closed and the governor assumes full control of the speed. At this point further opening of the throttle fails to increase the turbine speed.

5. Readings are checked by gradually closing the throttle, thus reducing the speed, and noting the speeds at the above points with falling speed.

6. The tests are then repeated for several intermediate positions of the auxiliary spring. The last test is made with the full-load limit switch on the verge of opening.

7. The governor weights in swinging out with increasing speed, move the operating lever and thus cause a slight change in the auxiliary spring length. This change should be noted.

The nature of the work requires that the speed measurements be highly accurate. The ordinary mechanical type tachometer is not satisfactory and best results are obtained from a high grade frequency recorder connected to the generator. This instrument records instantaneous frequency (which is equivalent to turbine speed) upon a high speed strip chart. The record thus obtained is of great aid. Regulation characteristics obtained in this manner represent those obtaining for the complete unit of turbine, governor and valve gear. The regulation of the governor alone, as obtained on a test block, is always somewhat wider as a certain amount of overtravel is allowed at both ends of the governor stroke in order to insure complete opening and closing of the admission valves.

Characteristic curves can be plotted from the data. These consist of the full-load and no-load lines obtained by plotting auxiliary spring length against speed for the two conditions. The movement of the auxiliary spring screw, which is a measure of the spring length, is more convenient to plot as it eliminates the difference in spring length between weights in and weights out positions. The upper and lower limit switch positions and normal speed line are also indicated. The ¼, ½, and ¾ load lines can also be plotted.

Test Curves

Figures 3 and 4 show typical regulation curves for the General Electric and Westinghouse governors, as plotted from data obtained as described above. The vertical normal speed line is intercepted by the no-load and full-load lines which slope downward from left to right. These two lines also intercept the upper and lower limit switch lines which define the range of load variation on the auxiliary spring. In general the characteristics for the two governors are alike within the range of the auxiliary spring but the Westinghouse governor allows greater movement of the auxiliary spring below normal speed.

Regulation of the machine at any position of the governor auxiliary spring is the corresponding distance between the no-load and full-load lines on the characteristic curves. It will be noted that these two lines are not parallel, but tend to convergence toward the bottom of the figure. Because of this fact, regulation is widest when the machine is operating with the auxiliary spring set near the upper limit switch. (This actually occurs with light load at normal speed.) Likewise, the regulation is narrowest when the auxiliary spring is near the lower limit switch (heavy load at normal speed).

Interpretation of Curves

A study of Figs. 3 and 4 shows several other pertinent conditions. For instance, the no-load line is seen to continue to the left, or low speed, side of the normal speed line before reaching the upper limit switch line. This allowance permits operating the turbine under governor control below normal speed and greatly facilitates the phasing-in operation. It will be noted also that the full-load line extends to the right of the normal speed line before reaching the lower limit switch line. Because of this, the governor may be adjusted so that the turbine will carry maximum load without being limited by normal swings in speed.

(To be concluded)

Saving of 50 per cent in the laying of eight conduits for electric cable in a trench is reported by J. J. Burri of the Staten Island Edison Co. Four 5-in. ducts for 33,000 v. and four 3½-in. for 6900 and 2300 v. were laid, 900 ft. of duct line in all, without the use of concrete envelope, thus requiring less excavation and needing no concrete forms. The material used was Transite, made of pressed asbestos by Johns-Manville, by building up on a steel mandrel a shell of desired composition and wall thickness. The conduit thus has a smooth interior and the material is strong, fireproof and resistant to corrosion. Joints were made with a special expansion coupling, one end of which is tapered inside to receive the end of a conduit tapered to fit; the other end of the coupling is bored to receive the straight end of a conduit with a rubber ring pressed between conduit and coupling to seal the joint. This joint permitted laying unbent conduit around a 23-deg. curve on 15-ft. radius.

Rolling-in *of* Boiler Tubes

Results of an Investigation of Boiler Tube Rolling with Emphasis on a New Method Successfully Used, Reported Before the Semi-Annual Meeting of the A.S.M.E.

By B. F. FISHER
and E. T. COPE
Detroit Edison Co.

ALTHOUGH much has been written about boiler shells and tubes, and riveted and welded joints, apparently nothing has been published in English about the method of fastening tubes into boiler shells and tube sheets. It is true that test methods have been applied for determining the water-tightness of these points, but such tests do not disclose the condition of the joint. Manufacturers of rolling tools furnish instruction booklets briefly explaining the use of the tools, yet engineering publications printed in English contain no information regarding this very important item of boiler design and construction.

Other parts of the boiler are designed with great care by engineers after careful study of strength of metals, effects of temperature, the permissible oxygen and carbon-dioxide content of boiler feedwater, etc., the production of the joints between the tube ends and the tube sheets or drums has been left largely to the ingenuity of the mechanics who assembled the structure. It appears, therefore, that the expanded tube joint, if its use is to be continued, should be subjected to scientific study, its limitations recognized, and an effort made along scientific lines to standardize field practice so that all the joints in a given boiler may be of maximum strength as determined by such investigation.

Knowledge of what constitutes a satisfactory rolled joint is now lacking. Once this knowledge is available and the correct procedure for rolling the joint has been established, the production of joints of maximum strength and tightness could be controlled. If the tubes could be machined to fit into carefully tooled tube holes, or if the tube ends could be shrink-fitted into the holes, the problem would be relatively easy. But liberal clearances must be allowed to permit easy introduction of the tubes into the holes, particularly in tight places, of which there are many in a modern large-capacity boiler.

Commercial practice and the demand for low-cost production puts precise machining out of the question. On the other hand, if the differences in diameters between the tubes and tube holes were constant to a micrometer tolerance and the tube-wall thickness did not vary, the problem of securing uniform joints would be relatively simple. Also if the surfaces of tube and tube holes which are to produce the joint were of uniform and standard finish, the production of uniformly tight and strong joints would not be so difficult.

But when joints are to be made between the surfaces of tube ends and tube holes in which the clearance may have any value from ten-thousandths to sixty-thousandths of an inch in a bank of tubes, where

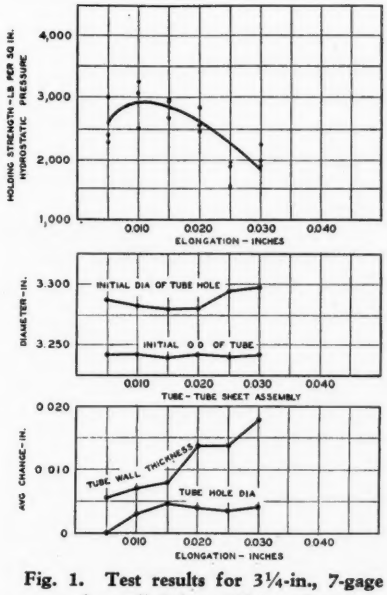


Fig. 1. Test results for 3¼-in., 7-gage tubes rolled into 2¼-in. plates

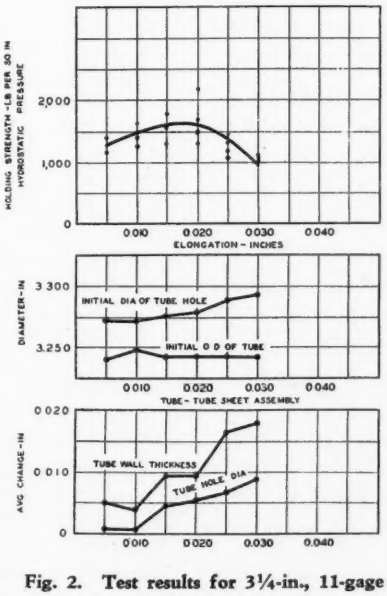


Fig. 2. Test results for 3¼-in., 11-gage tubes rolled into 1-in. plates

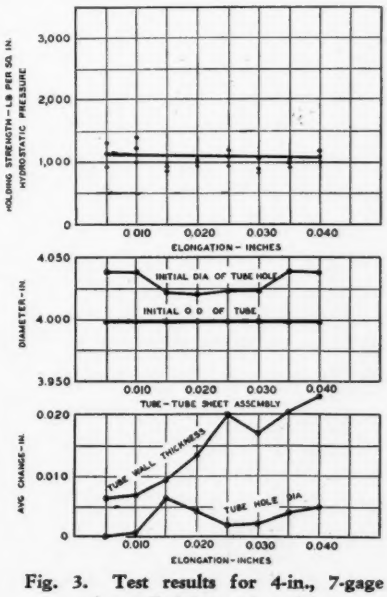


Fig. 3. Test results for 4-in., 7-gage tubes rolled into 1-in. plates

the tube holes are reamed to commercial finish yet the tubes are covered with mill scale or are indifferently cleaned, one should not be surprised if a considerable percentage of the joints shows leaks when the assembled structure is subjected to a hydrostatic-pressure test. Neither should one be surprised if the rerolling operation causes leaks in joints accepted on the first hydrostatic test, nor that such joints fail after a comparatively short period of service.

The production of a joint by expanding a tube into a tube hole entails the execution of two distinct phases of the rolling-in operation. The first consists of stretching the tube wall until there is contact between the outside surface of the tube and the inside surface of the tube hole. A joint does not begin to exist until this contact has occurred. As already noted, the difference in diameter of the tube and the tube hole is by no means constant in any group of prospective joints. Therefore, the amount of expanding of the tube necessary to produce contact between tube wall and tube hole may vary widely from tube to tube.

Consequently, this fact must be taken into account when producing a joint. The second phase of the rolling-in operation consists of giving the tube wall further permanent stretch, thus pressing the outside surface of the tube against the inside surface of the tube hole. This pressure alone is the source of fluid tightness in the joint. Also this pressure, coupled with the friction between the two metal surfaces, is the source of the strength of the joint which holds the tube in the tube hole when pressure is applied within the boiler.

Since the pressure between the two surfaces is the only variable in any given case entirely within the control of the mechanic doing the assembling, it might be concluded at once that the greater the expansion the better the joint. That this is not true has been demonstrated by tests which show that both the tube wall and the metal surrounding the tube hole are subjected to severe cold working when excessive expansion is practiced. When a tube must be replaced in a tube hole which has been heavily over-expanded, the hole is badly distorted and should be reamed to true it up and to remove the metal which was overstressed at the previous rolling.

This paper presents the results of a study of the expanding of boiler tubes and proposes a method which, over a five-year period, has produced uniform joints of optimum strength. In this method the severe cold working of the tube and drum metal, because of excessive expanding of the tubes, has been either avoided entirely or reduced to a minimum.

Three methods of tube expanding are generally accepted. These are the tube-bulge method, the uniform-expander-entrance method, and the measured-energy-input method. In the tube-bulge method, a few tubes in a bank, used as samples, are expanded until their outside diameters are increased a definite amount (1/32 in. usually) over the nominal tube-hole diameter. This measurement is made immediately next to the tube sheet or drum on the gas side in a water-tube boiler and the water side in a fire-tube boiler. The amount of tube bulge is measured by a gage of fixed opening. The expanding or rolling operation is carried out until this outside gage fits the bulge of the tube. After the operator gets the "feel" of rolling-in these samples, he proceeds to roll-in the remainder without measurement.

In the second method of tube expanding, the tool is entered a fixed distance into all the tubes in a given bank. This distance is determined by trial on a few tubes and the stop is set. In the uniform-energy-input method all joints are rolled-in with a consumption of a given amount of energy expressed in watthours or horsepower-hours.

In these methods of tube expansion there is no way of knowing definitely when the tube surface contacts the tube hole. Also, there is no way of knowing how much the tube is expanded after contact occurs.

The elongation method of tube rolling, as developed by the company with which the authors are associated, more nearly fills the specifications for an ideal method than does any one of the other methods noted. In this method advantage is taken of the fact that the tube is loose in the tube hole until the first phase of the rolling-in is completed. It further takes advantage of the fact that during the expanding operation the wall of the tube within the tube sheet is thinned. The metal is squeezed between the expanding tool and the surface of the tube hole and is forced to flow axially.

This moves the tube axially a measurable amount, which is a function of the degree of the expansion. The only extra tool required by this method is a dial indicator fitted with the proper-size clamp, so that the indicator may be readily attached to tubes. The tube is inserted into its tube hole and manually held in place. The clamp extends half way around the tube and bears at three points to prevent rocking. The end of the shaft of the dial indicator rests on the tube sheet or drum. The expanding operation proceeds, using a "parallel" expanding tool.

During the first phase the needle of the dial indicator vibrates until the tube has been stretched into circumferential contact with the tube hole. At the instant of this contact the needle comes to rest, indicating that the first phase has been completed, and item two of the ideal method of expanding has been met. Continued expansion further stretches the tube wall into firmer contact with the hole and squeezes it so that axial flow occurs. This axial flow causes movement of the dial-indicator needle. The amount of movement of the needle necessary to produce the best joint has been established by tests.

Sample joints were produced by expanding short lengths (usually 15-in. long) of boiler tube into blocks of boiler plate. Each block of plate had one reamed hole of nominal diameter, finished in the same manner as the tube holes in a boiler drum. One end of each sample was closed by welding in a steel disk.

Elongation during expanding was indicated by a dial indicator. The results of these tests are shown in Fig. 1 to 3, inclusive. In these figures the holding strength is expressed in pounds per square inch hydrostatic pressure necessary to cause failure of the joint at room temperature. Failure occurs when the tube slips in the tube hole. The clearance (difference in diameters) between the tube and the tube hole is shown by the width of the band between the tube curves, ("Initial Diameter of Hole" and "Initial OD

of Tube.") In some cases this band is of almost uniform width, whereas in others, the width varies considerably. The tube-wall thickness decreases at a relatively uniform rate with increase in elongation, as would be expected, whereas the increase in tube-hole diameter does not follow the increase in elongation. This condition might be expected if the tubes were made from much softer steel than were the tube sheets.

Tubes in several boilers have been expanded using the elongation method and the results have been highly satisfactory. Among these are the following: Boiler No. 14, Trenton Channel power plant, operating at 400 lb. per sq. in.; two boilers at the Ford Motor Co., Dearborn, Mich., operating at 1425 lb. per sq. in.; two boilers at the Springwells Plant of the Detroit Board of Water Commissioners operating at 400 lb. per sq. in. There are several other matters in the tube-rolling problem which merit investigation. Some of these are: (a) The effect of the condition of finish of the surfaces to be forced together in rolling-in a joint. (b) The effect of the relative hardness of tube and tube sheet on the tightness and holding strength of the joint. (c) The effect of grooves in the tube hole on holding strength and rigidity of the joint.

In this paper little has been said about the tool used for rolling-in the joint. This tool, like most others, has been the result of growth over a period of years. There does seem to be a need for some further development in the tools ordinarily used. In the work done in Germany for the Association of Owners of Large Boilers, A. Thum and W. Ruttmann, the investigators, lay great stress on the effect of rate at which the joint is formed. This rate is a function of rate of feed of the tool and the number of revolutions of the tool to form the joint. They have merely touched on this matter and state that it should be studied further.

Installation of Small Pipe Lines

By S. H. COLEMAN

POOR DESIGN or improper installation of the smaller piping in power plants is a major source of many operating and maintenance difficulties. Among these smaller lines subject to care in design and installation, and some of the methods by which trouble can be minimized, are:

1. Small piping—general.

a. Proper material of requisite strength for class of service, supporting arrangement, drainage and adequate sizing are essential.

b. Use globe valves wherever throttling, close regulation or frequent operation is necessary. Where valves are infrequently operated or pressure drop is important, use gate valves.

c. Equip all frequently operated valves in inaccessible places with extension stems or chain wheels.

d. Where a number of small valve wheels are grouped together, brass name plates designating the service are of great assistance to the operator.

e. Arrange piping to avoid congestion and simplify maintenance. Paint or stencil piping to designate service.

f. Apply pipe compound only on the male threads of threaded joints. When piping is cut, ream out any burrs on the inside of the cut. Use a hacksaw rather than a wheeled cutter when cutting the smaller size piping and reaming will be simplified.

2. Instrument and control piping.

a. Wherever possible, use brass or copper tubing in this service. Scale and corrosion will eventually cause difficulty where iron or steel piping is installed.

b. Provide a means of blowing clear all instrument and control lines. Periodic attention to this operation will prevent stoppage of the line by foreign material.

c. Proper sloping of the piping is important. Low points in which sediments can accumulate, or high points subject to air binding, are trouble makers. Where necessary, provide sediment catch-alls or, air vent valves. To insure proper sloping of long overhead stretches of small tubing, install the piping in some form of conduit. Channel iron is very suitable for this purpose.

d. Pressure gages or other equipment subject to damage from high temperatures must be protected from contact with live steam by means of water legs or syphons.

e. Provision should be made against variations in the static head of water which adversely affect the accuracy of instruments and control equipment. Strict adherence to the equipment manufacturers' installation instructions is usually all that is necessary to avoid trouble from this and other sources.

f. Strainers or filters should be provided on all lines supplying water and air to pilot valves, operating cylinders and other auxiliary control equipment.

3. Piping used in draining, free-blow, leak-off, or other similar service.

a. Install separate lines for each individual service on each piece of equipment wherever possible. Make provision for the observation of the open ends of these lines to simplify detection of waste or leakage.

b. Provide splash proof funnels at all points where visual overflow of water services is desirable.

c. Unless absolutely necessary, do not bury small drainage piping, use trenches.

d. Provide plenty of clean-out plugs on complicated drainage systems. Brass plugs are easy to remove.

4. Steam trap piping points.

a. When locating traps, keep them off the floor to simplify plant housekeeping.

b. Provide test valves to determine trap leakage.

c. Have due regard for discharge line pressure when selecting trap size.

d. Equip all traps with strainers on the inlet side, a means of by-passing trap for repairs, and check valves on the discharge side to avoid backflow when line drained is out of service.

Burning Iowa Coal *on* Underfeed Stokers

The State University of Iowa plant at Iowa City, burns a score of Iowa coals successfully over a period of two years and replaces two existing chain grate stokers to improve fuel burning efficiency and increase boiler capacity

SINCE THE ADVENT of stokers in the middlewest, chain grates have been the accepted method of burning the low grade, low fusing temperature ash, coals of that region. In recent years, however, progress in design combined with the successful application of water walls and better knowledge of combustion has done much to broaden the field of application of underfeed stokers and they gradually encroached on the chain grate domain. This encroachment progressed to the point where the chain grate was supreme only in Iowa where extensive deposits of low grade bituminous ranging from 8500 to 10,000 B.t.u. per lb., high in ash and sulphur, exist. Spasmodic efforts to burn these coals on underfeeds met with indifferent success until the State University of Iowa made a well designed installation and burned 22 of these coals with such success that two existing chain grate stokers, one natural and one forced draft, were recently replaced with underfeeds.

In 1927 the university built a central power plant to replace four old plants and to handle more efficiently the growing needs of the university. Four 612-hp., 175 lb., 100 deg. F. superheat Stirling boilers fired by natural draft chain grate stokers were installed in the boiler room and two 1000-kw., 2300 v., 2 ph., 60 cycle Westinghouse extraction condensing units, in the turbine room. In addition, an existing 156-kw. water wheel unit, with its draft tube and substructure was incorporated as an integral part of the new plant. Later a water works and pumping station was added so that the plant now supplies heat, water, light and power to the entire campus covering an area of perhaps a square mile.

The Iowa River divides the campus into two parts, the east, with the university building and administration offices, and the west, with the field house, hospital and medical college. At the south edge of the campus the university has a dam, with the hydraulic laboratory at the west end and the new power plant at the east end. This dam is hollow and serves as a tunnel for taking the steam lines, water lines and electrical conduits under the river to the west campus.

As originally installed, the four boilers were on one side of the firing aisle and were served by a 205 ft. concrete stack 9 ft. 6 in. in diameter at the top. Space was provided for four more boilers on the other side of the firing aisle. Link-Belt coal and ash handling and storage equipment was installed at the end of the boiler room. This consists of a track hopper, feeder, single roll crusher, Peck carrier and two six-car bunkers and a power driven weigh larry. Ash is collected in industrial cars and elevated in a skip hoist to an overhead hopper. The building may be extended further to give an H-shaped boiler room with four rows of boilers and with the coal handling equipment and stacks at the crossbar. Three Allis-Chalmers 300 g.p.m. boiler feed pumps were installed, two steam and one motor driven, and the feedwater (first raw river water but since the completion of the water works, treated and filtered water) is treated by a Cochrane hot process softener.

In 1930 two more boilers, Nos. 7 and 8, were installed on the other side of the aisle, a second stack built to serve them, and a 500 g.p.m. Dayton-Dowd boiler feed

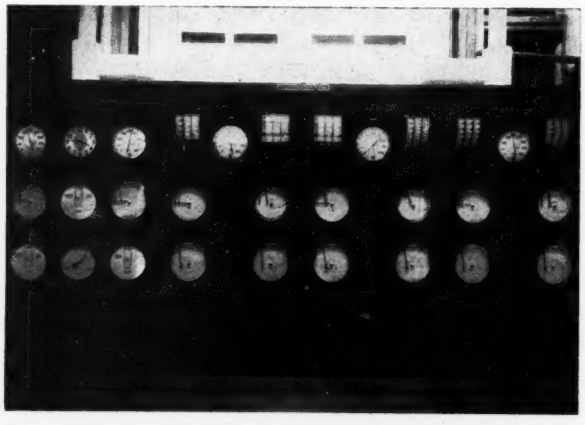


Fig. 1. Close up of the boiler control panel shown in Fig. 3. The master panel is on the left and the three individual boiler panels on the right. A complete instrument assembly is provided and the combustion control system is designed for automatic compensation from the CO_2 determinations

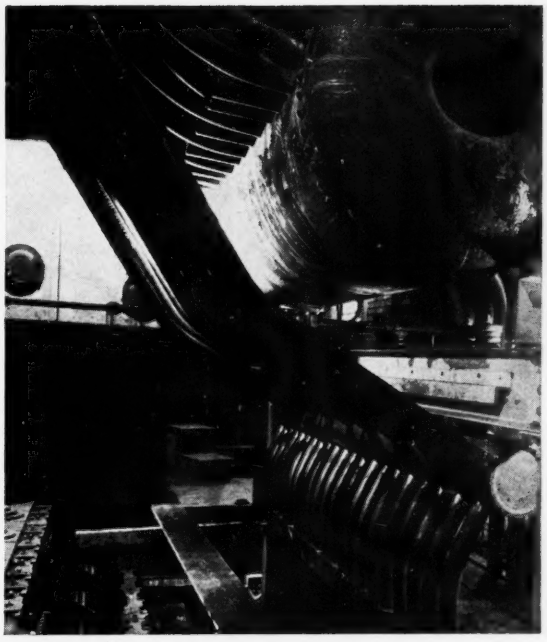


Fig. 2. Details of the boiler changes. The front row of tubes of the bent tube boilers were brought forward to serve as a slag screen and dropped down to the bridge wall header as shown. The stub tubes rolled in to fill the holes in the mud drum are also visible

pump added. Although designed for 150 per cent rating natural draft did not give the flexibility and capacity desired with the wide variety of low grade coal used. For this reason one of the new units, No. 7, a 630-hp., 200 lb., 100 deg. F. superheat, Murray bent tube boiler, was installed with a forced draft zoned chain grate, while No. 8, a 612-hp., 175 lb., 100 deg. F. superheat Stirling, was installed with a natural draft chain grate as before.

Operation showed that while forced draft on the chain grates improved conditions materially, it did not bring them up to what might reasonably be considered modern plant performance. When additional capacity was needed, serious consideration was given to pulverized fuel firing but this was finally abandoned in favor of an underfeed stoker.

Naturally this decision brought about considerable criticism and not a little active opposition because it was an accepted fact in many quarters that Iowa coal could not be successfully burned on underfeed stokers. Failures along this line in early days still burned bright. Nevertheless A. A. Smith, superintendent of buildings and grounds, and C. F. Robinson, chief engineer, were convinced that progress in stoker and furnace design was such that they could succeed in burning at least a limited number of Iowa coals on such a stoker with considerable increase in efficiency and capacity. A careful investigation by Mr. Smith, Mr. Robinson and several members of the Board of Education confirmed this decision.

The new unit, Boiler No. 6, was installed in 1932. (Although space is available for No. 5, it has never been installed, the seven boilers installed are Nos. 1, 2, 3, 4, 6, 7 and 8.) It is a 605-hp., 225 lb. Murray Type A straight tube boiler fired by a Taylor underfeed stoker with a projected grate area of 156.4 sq. ft. The stoker is equipped with rotary ash discharge and is driven by a Hele-Shaw hydraulic transmission. It is equipped with Vulcan soot cleaners and Copes feedwater regulators. The forced draft fan, a Sturtevant size 80, installed in the basement, is dual driven by a General Electric 40-hp., 220 v., 1750 r.p.m. motor and a Murray 40-hp., 170 lb., 1750 r.p.m. non-condensing turbine.

Over a period of 3 yr. 50,000 t. of coal have been burned, of which 35,000 t. represented 22 Iowa mines. The other 15,000 t. were some of the poorer grades of Illinois and Indiana coals. Typical analyses of these coals, taken from a formal A.S.M.E. test conducted by The Commercial Testing & Engineering Co. of Chicago, are given in the accompanying table. These coals range from 8500 to 10,000 B.t.u. per lb. Most of them with high ash and high sulphur content and low fusing temperature ash. The average of these coals is probably 9200 B.t.u. per lb. for screenings and 9600 B.t.u. for picked run of mine. During this period but one coal gave difficulty; that was a washed coal with very low ash content and fusing temperature. Whether it will eventually be possible to burn this coal at light loads without water cooled tuyeres is debatable and unfortunately not likley to be settled soon for the coal was part of a small shipment brought in from the Illinois field during a threatened strike and it is not likely that more will be purchased.

Out of these months' work and experience with a score of coals, the engineers have summed up the secret of burning Iowa coal on underfeed stokers as, "Be satisfied with a reasonable rating—reasonable CO_2 and do not mix the coals." By reasonable rating is meant 200 to 250 per cent and by reasonable CO_2, 10 to 13 per cent.

As a result of the success obtained on No. 6 boiler the chain grates under Nos. 7 and 8 were replaced with Taylor underfeeds (projected area 169.8 sq. ft.) the early part of this year, No. 8 going into service late in January, and No. 7 late in April. The new stokers have a hydraulic drive by which each ram is individually actuated by oil pressure. The change was made without moving the boilers although some changes were

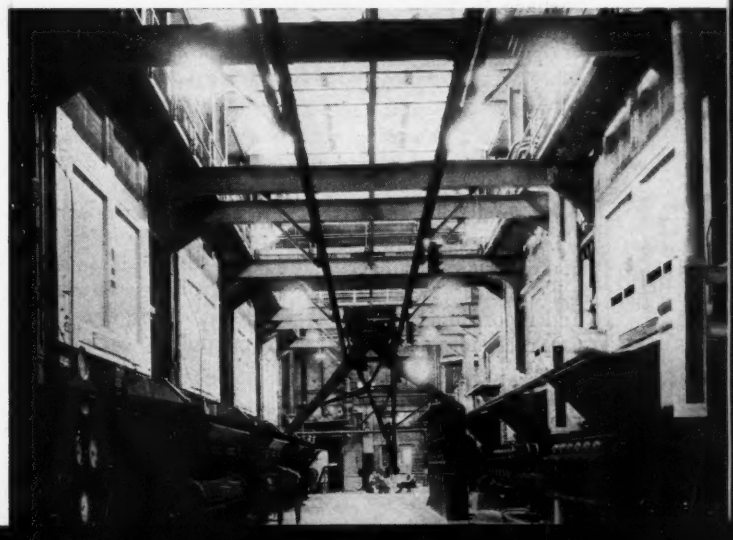
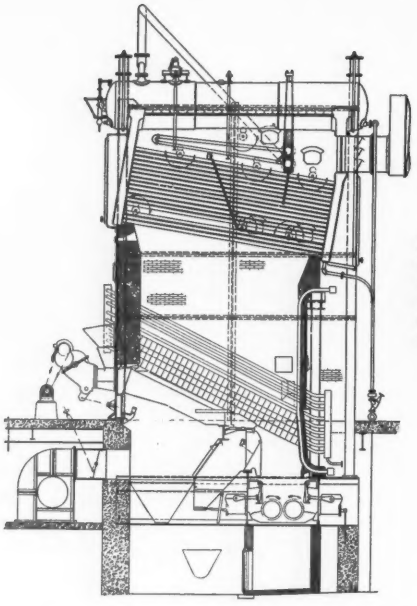


Fig. 3. The firing aisle with the three new underfeed stokers on the right and four old chain grates on the left. Boiler feed pumps and water treating equipment are at the far end of the aisle behind the old boilers. Coal bunkers are directly above the camera and coal is delivered to the stoker hoppers by the weigh larry



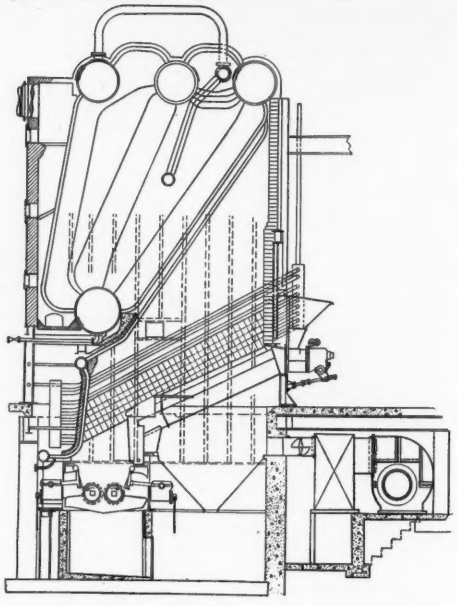


Fig. 4. (Left) The original underfeed stoker installation which went on the line June, 1932, and (right) general arrangement of the bent tube boilers recently converted from chain grate to underfeed stoker firing

made in the boilers themselves and American Engineering Co. water walls were added. On both units the front row of tubes was lengthened, moved forward to serve as a slag screen, with the lower ends of the tubes rolled in the top header of the rear water wall. The side walls are also water cooled by nine tubes, the lower six covered with cast-iron blocks, the top three bare. De Wolf suspended furnace walls are used in both of these boilers, for, although the original solid refractory wall in No. 6 has required no repairs some cracks have developed and it was felt that the ease of maintaining a tight furnace with the suspended wall justified the slight additional expense.

Summary of 24 hr. acceptance tests on boiler No. 6 and analysis of coals used. Stoker guarantees called for 300 per cent maximum rating, which was met easily, but a drop in steam load over the last few hours of last test reduced the average rating to 284 per cent

Test No.	2	1	3	4
Coal	Appanoose Co. No. 1	Marion Co. No. 12	Polk Co. No. 8	Appanoose Co. No. 1
Rating, %	100	150	200	287
Equiv. Evap., lb. Water per lb. Coal	8.447	7.666	7.634	7.82
Efficiency, %	84.1	80.5	78.5	78.0*
Sulphur, %	5.11	4.10	5.67	5.11
Ash, F. Temp., %	1967	2037	1955	1967
B.t.u. per lb.	9740	9241	9441	9241
Proximate Analysis, as fired:				
Volatile, %	33.46	31.95	32.04	33.46
Fixed Carbon, %	36.04	33.84	35.02	36.04
Ash, %	14.21	16.50	16.49	14.21
Moisture, %	16.29	17.71	16.45	16.29

These three boilers, Nos. 6, 7 and 8, will now carry the entire load, with the original four boilers kept as standby. The new units are equipped with a Garrick automatic combustion control system centralized with a complete complement of instruments and recorders, on a four panel gage board, one master panel and three individual boiler panels. This board with the combustion control equipment was supplied by The Hays Corp. and Carrick Engineering Co. The board is equipped with Ashcroft indicating gages, Cochrane flowmeters and recording thermometers and pressure gages, Hays CO_2 recorders and Hays recording and indicating draft gages.

As shown by Fig. 1, the master panel has an indicating feedwater pressure gage, a clock, an indicating steam pressure gage, a recording indicating and integrating meter for feedwater flow and temperature (totalizing the flow to all three boilers) and recorders for header steam pressure and temperature. The master pressure regulator is in the center of the lower row of instruments with the three individual boiler loaders above and one each side. Individual boiler panels have two three-pointer draft gages, indicating steam pressure gage, steam pressure and temperature recorder, CO_2, draft and flue gas temperature recorder, steam flow and feedwater flow indicating and recording meters. In the center of the panel are switches and push buttons for changing from automatic to hand control.

The combustion control operates through the master pressure regulator to maintain the steam header pressure within a range of 4 lb. Changes in steam pressure from normal actuate this master, which in turn moves cams in the individual boiler loaders and through them changes the draft loss through the individual boilers. These individual cams are designed specifically for each boiler from draft loss tests between the first and third pass. Fuel is fed according to the draft loss through the boiler. As the coal feed is changed the cam in the feed control repositions a differential draft element (measuring the draft loss) which actuates the stoker drive to give the coal feed determined by test as normal for that particular draft loss and CO_2. A similar differential element, compensated by mechanical connection to the coal feed control, follows the boiler loader to vary the coal feed.

Variations from test conditions due to coal quality or dirty tubes is compensated for by the CO_2 meter so as to maintain the desired CO_2. Overfire draft is maintained constant by a draft regulator element which actuates a damper in the duct between the constant speed forced draft fan and the stoker windbox.

Control of the dampers and coal feed is accomplished through Mercoid magnetic switches and small reversing control motors. In the first case the control motors drive small oil pumps and operate the dampers through

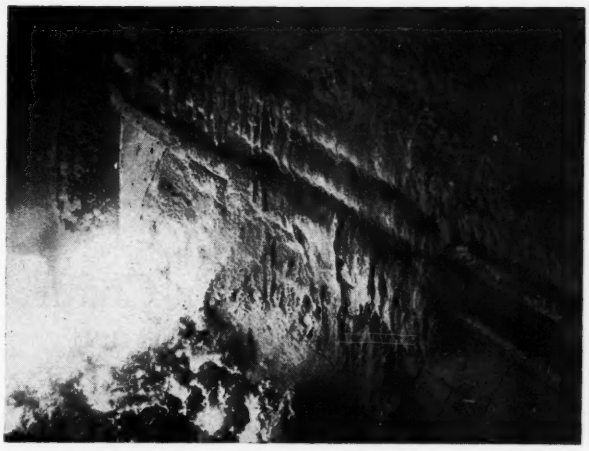


Fig. 5. One of the furnace walls showing the slag cooling ledge an important detail of the furnace design. Molten slag is chilled and drops off in solid form on top of the fuel bed and thus is prevented from running down into the stoker

hydraulic cylinders; in the second case the motors are geared directly to the stoker speed control. The CO_2 compensator has sufficient range to take care of coal variations of from 8000 to 12,500 B.t.u. without manual adjustment.

Boilers may be loaded evenly or not, as desired, by means of an adjustment on the individual boiler loaders and the CO_2 may be changed by a similar adjustment on the CO_2 meter. Any boiler can be shifted to base load by changing the selector switch for the breeching damper from automatic to hand control and operating the damper by push button. When this is done all controlled elements follow the movement of the breeching damper. In addition the boiler outlet damper, forced draft dampers, coal feed and CO_2 compensator may be moved in either direction by push buttons. The forced draft fans and stoker motor may also be started and stopped by pushbuttons from the board. In case of power failure, dampers and coal feed can be operated manually from hand wheels. To take care of emergencies of this kind, one stoker drive and one forced draft fan is provided with dual drive. A complete description of this combustion control system will be given in a later issue.

In winter the steam load runs about 2,000,000 lb. per day and even in summer the steam load runs up to peaks of 50,000 lb. per hr., due largely to steam use in the laundry, field house and hospital so that fuel cost and boiler efficiency are a considerable item. It is expected that the new units will show an excellent return on the investment and as soon as they have been operating a sufficient length of time to give comparable before and after data, these costs will be compiled and presented in a later article.

Working Capital *for* Industries

Federal Reserve Act Liberalizes Credit to Established Businesses

THROUGHOUT the depression, the working capital of nearly every industrial establishment has been depleted if not completely exhausted. This condition has been a distinct influence in retarding recovery. The managers of many such concerns have recognized the need of new and modern equipment to aid them in meeting competition in their particular fields and have confidence in their ability to meet the added financial burden necessitated by an improved plant but have been unable to secure loans for this specific purpose.

Such a condition as this exists in many power plants where engineers' recommendations for badly needed improvements have been turned down because capital was not available. Through Government legislation, however, financial institutions are now given the backing of Federal Reserve banks in supplying capital to established industrial and commercial businesses. This is accomplished under the provisions of Section 13b of the Federal Reserve Act as amended by the Act of June 19, 1934, which reads in part as follows:

"Sec. 13b. (a) In exceptional circumstances, when it appears to the satisfaction of a Federal Reserve bank that an established industrial or commercial business located in its district is unable to obtain requisite financial assistance on a reasonable basis from the usual sources, the Federal Reserve bank, pursuant to authority granted by the Federal Reserve Board, may make loans to, or purchase obligations of, such business, or may make commitments with respect thereto, on a reasonable and sound basis, for the purpose of providing it with working capital, but no obligation shall be acquired or commitment made hereunder with a maturity exceeding five years.

"(b) Each Federal Reserve bank shall also have power to discount for, or purchase from, any bank, trust company, mortgage company, credit corporation for industry, or other financing institution operating in its district, obligations having maturities not exceeding five years, entered into for the purpose of obtaining working capital for any such established industrial or commercial business; to make loans or advances direct to any such financing institution on the security of such obligations; and to make commitments with regard to such discount or purchase of obligations or with respect to such loans or advances on the security thereof, including commitments made in advance of the actual undertaking of such obligations. Each such financing institution shall obligate itself to the satisfaction of the Federal Reserve bank for at least 20 per centum of any loss which may be sustained by such bank upon any of the obligations acquired from such financing institution, the existence and amount of any such loss to be determined in accordance with regulations of the Federal Reserve Board: Provided, That in lieu of such obligation against loss any such financing institution may advance at least 20 per centum of such working capital for any established industrial or commercial business without obligating itself to the Federal Reserve bank against loss on the amount advanced by the Federal Reserve bank: Provided, however, That such advances by the financing institution and the Federal Reserve bank shall be considered as one advance, and repayment shall be made pro rata under such regulations as the Federal Reserve Board may prescribe.

"(c) The aggregate amount of loans, advances, and commit-

ments of the Federal Reserve banks outstanding under this section at any one time, plus the amount of purchases and discounts under this section held at the same time, shall not exceed the combined surplus of the Federal Reserve banks as of July 1, 1934, plus all amounts paid to the Federal Reserve banks by the Secretary of the Treasury under subsection (e) of this section, and all operations of the Federal Reserve banks under this section shall be subject to such regulations as the Federal Reserve Board may prescribe.

"(d) For the purpose of aiding the Federal Reserve banks in carrying out the provisions of this section, there is hereby established in each Federal Reserve district an industrial advisory committee, to be appointed by the Federal Reserve bank subject to the approval and regulations of the Federal Reserve Board, and to be composed of not less than three nor more than five members as determined by the Federal Reserve Board. Each member of such committee shall be actively engaged in some industrial pursuit within the Federal Reserve district in which the committee is established, and each such member shall serve without compensation but shall be entitled to receive from the Federal Reserve bank of such district his necessary expenses while engaged in the business of the committee, or a per diem allowance in lieu thereof to be fixed by the Federal Reserve Board. Each application for any such loan, advance, purchase, discount, or commitment shall be submitted to the appropriate committee and, after an examination by it of the business with respect to which the application is made, the application shall be transmitted to the Federal Reserve bank, together with the recommendation of the committee."

Grant or Refusal of Application

In making any loan to or purchasing the obligations of any established industrial or commercial business or making any commitment with respect to such a loan or purchase, the Federal Reserve bank shall ascertain to its satisfaction:

(1) That the circumstances are exceptional;

(2) That the obligor upon the obligation to be purchased or to evidence such loan is an established industrial or commercial business located in its district;

(3) That the proceeds of such loan or purchase are to be used to provide working capital for such business;

(4) That such obligor is unable to obtain requisite financial assistance on a reasonable basis from the usual sources;

(5) That the financial condition and credit standing of the obligor and indorsers, if any, upon such obligations, and the value of the security offered, if any, justify the granting of such accommodation on a reasonable and sound basis; and

(6) That the transaction will comply with the requirements of the law and of this regulation with regard thereto and, insofar as such reserve bank may be able to ascertain, does not involve a violation by any person of the provisions of section 22 of the Federal Reserve Act.

To procure a loan, first ask your own banker for a loan to meet your requirements. If the bank will not lend on ordinary terms, suggest that it participate in a 13b loan from the Federal Reserve bank of the district. If your bank will participate it will, of course, start negotiations with the reserve bank. If not, go to the reserve bank yourself and tell your story fully and frankly. You will find out whether you are an eligible borrower under 13b. If you are, you will be asked to make out an application form, and the bank will undertake the necessary investigation to check up on your statements and to draw a complete picture of your business situation. The case will be passed on by the bank's Advisory Committee of business men, and then by the bank's officials. If they decide to recommend a loan, and an agreement is readily reached regarding security, maturities, etc., the whole process ought not to take more than three or four weeks.

If you have any reason to think that your credit needs could possibly come under the intent of the industrial loan law, it would pay you to see your banker and, if necessary, to visit or write to the Federal Reserve bank.

Rating of Roller-Chain Drives

REFERENCE TABLES giving horsepower ratings for roller transmission chains are commonly based upon certain allowable working pressures per square inch of projected bearing area at the chain joints. The allowable working load is assumed to increase in proportion to the projected area of the pins and to decrease with an increase in chain velocity and an increase in the "centrifugal pull" of the chain.

An analysis of the bending action of the links at both driving and driven wheels and the work of friction between pins and bushings yields an algebraic expression for the heat generated per minute, or for the rate of wear in the chain. This is proportional to the rate of elongation of the chain; and this rate of elongation is found to be directly proportional to the pitch, the length of the bushing, the number of links in the chain, and the product of the number of teeth in the two sprockets (very nearly).

A set of tables developed (based upon chain velocity and the number of teeth in both sprockets) was presented by G. M. Bartlett, professor of machine design, Purdue University, and consulting engineer, Diamond Chain & Mfg. Co., before the A.S.M.E. The horsepowers taken from these tables are such as to produce approximately the same rate of elongation in all drives whose design and operation conform to average conditions.

Similar tables computed on the basis of the speed of the smaller sprocket instead of the chain velocity were given. These tables allow for the extra pull on the chain due to centrifugal force and for the chain lengths and center distances necessary to keep the rate of elongation within the limits allowed. An examination of the tables show that, with certain combinations of sprocket teeth and chain lengths, loads twice as great as those usually given in tables can be transmitted. And these figures seem to be supported by acutal practice.

The subject of limiting speeds for sprockets is important and three sets of limiting conditions investigated were reported on, namely: (a) the effect of a single impact between chain rollers and sprocket teeth, (b) the energy of impact per tooth per minute, and (c) the effect of centrifugal action. Tables have been compiled giving maximum chain velocities and sprocket speeds, based upon these investigations, for various chains and various numbers of teeth in the sprockets. These show the conditions under which certain chains can be operated at velocities above 3000 f.p.m. and other conditions under which the same chains should not be operated at more than 240 f.p.m.

Waste Heat Recovery From Diesel Engines

Charts Facilitate the Solution of Problem Involving the Quantity of Steam or Hot Water Obtainable from Two and Four Cycle Engines

By EMIL EHMSEN, Kiel, Germany

IN ORDER to improve the economy of Diesel installations, there is an increasing tendency to utilize the exhaust gases of engines in waste heat boilers for the purpose of producing hot water or steam. The curves of Figs. 1 and 2 were drawn to shorten calculations for determining the recovery which might be expected from waste heat boilers under given operating conditions. In the following paragraphs the theory is treated only so far as it serves to make the curves understandable.

Heat available can be calculated from the weight and the temperature of the exhaust gas. In four stroke cycle engines the weight of exhaust gas is directly dependent on the piston displacement of the engine, and, in the two stroke cycle engines on the displacement volume of the scavenging pump and is virtually independent of load as changes at partial load due to the smaller weight of fuel injected, is negligible. The gas temperature is dependent upon the type of engine, whether four or two stroke cycle, on the load and somewhat on the design as smaller cylinders and correspondingly higher speeds give higher temperatures due to faster successive explosions.

In Curve I of both Figs. 1 and 2 are given the exhaust temperatures for the individual load conditions. On account of the cooling effect of the scavenging air, temperatures are lower for two stroke cycle engines than for four stroke cycle engines. Under normal conditions, an exhaust temperature at full load of 680-720 deg. F. can be counted upon in four stroke cycle engines as compared to 560-600 deg. F. in two stroke cycle engines. In the curves these exhaust temperatures have been assumed, although naturally any optional measured temperature can be entered in it and used as a basis for calculations.

The weight of the waste gas, W, is equal to the weight of air delivered to the cylinders, A, plus the weight of the fuel, F, or $W = A + F$. In four stroke cycle engines the weight of air drawn into the cylinders each second is

$$A = (N \times V \times e \times s) \div (2 \times 60) \qquad (1)$$

Where N is the speed of the engine, V the total piston displacement in cubic feet, e the volumetric efficiency (may be assumed as 0.9) and s the specific weight of the air. In two stroke cycle engines the weight of the air delivered to the engine cylinders depends upon the scavenging pump size and efficiency so

$$A = (N \times V \times r \times E \times s) \div 60 \qquad (2)$$

Where N, V and s are the same as in Eq. 1 and r is the ratio of scavenging pump to engine displacement and E is the volumetric efficiency of the scavenging pump. On the average, E can be assumed as 0.96 and r as 1.35.

Since large engines are more commonly built for the two stroke cycle, the limits in the curves were taken as 0 to 1600 br. hp. for four stroke cycle and 0 to 8000 br. hp. for two stroke cycle types. For higher powers the values may be increased proportionally to the power. The useful quantity of heat Q is determined not by the exhaust temperature T_E, but by the possible temperature drop of the waste gases. This temperature drop, T, can be calculated readily after finding the steam temperature T_S or the hot water temperature T_W, through simple subtraction.

In this, however, two things must be considered. First, in order to attain an economical installation, as shown by experience, the temperature of the waste gases leaving the boiler should be about 108 deg. F. above the steam or hot water temperature. With this limitation, temperature drop in degrees Fahrenheit is, therefore:

$$T = T_E - T_S - 108 \qquad (3)$$

$$\text{for steam, or } T = T_E - T_W - 108 \qquad (4)$$

for hot water. Second, the waste gases should not be cooled below 320 deg. F. for with high sulphur fuel the acid formed by the condensation would cause serious corrosion of boilers in a short time. Consequently, $T_E - T$ must be equal to or greater than 320 deg. F.

The useful quantity of heat, Q, can be read from Curve II of either figure for any optional waste gas weight and for any temperature drop. This is a graphical solution of the equation,

$$Q = Wc\ (T_e - T_s \text{ or } _w - 108) \qquad (5)$$

Where c represents the specific heat of the waste gases at constant pressure. Quantity of steam, S, produced hourly may be calculated from, Q, the useful quantity

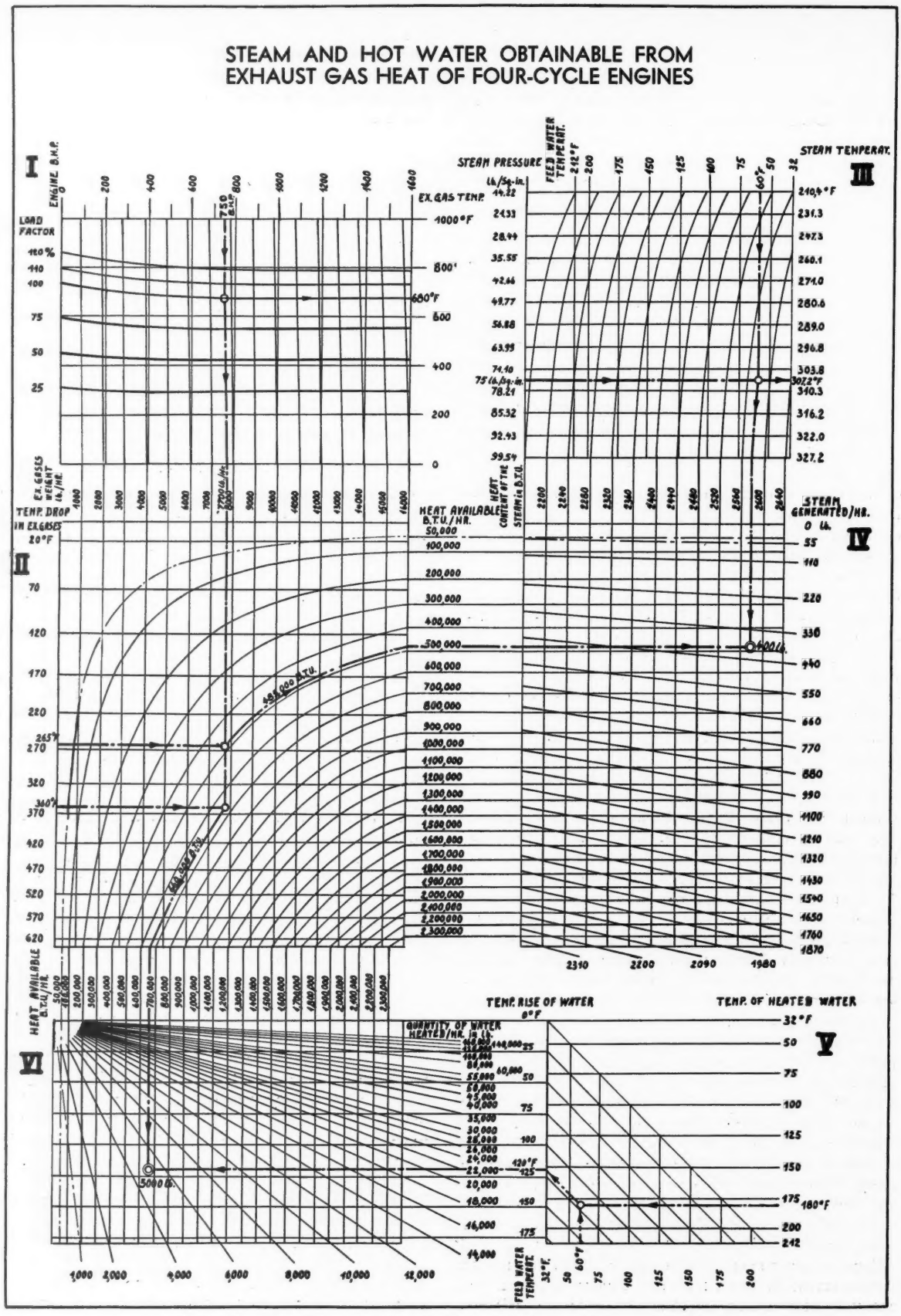


Fig. 1. Four cycle engine chart for the solution of steam and hot water problems

of heat, H, the heat added to the steam, and E_s the boiler efficiency by means of the equation

$$W = Q E_s \div H \qquad (6)$$

This can be read from Curve IV. Here the boiler efficiency is assumed somewhat lower than is actually attainable because of the steam moisture. The heat added to the steam can be taken from Curve III for any desired steam pressure and feedwater temperature.

Quantity of hot water H produced hourly may be calculated from Q, the useful quantity of heat T_z, the temperature increase of the water T and E_n the boiler efficiency by means of the equation,

$$H = Q E_s \div T_z \qquad (7)$$

This may be read from Curve VI. The temperature increase of the water, T_z, a simple subtraction, may be determined from Curve V.

Determination of the hourly quantities of hot water and steam are shown by the following examples:

EXAMPLES FOR FOUR STROKE CYCLE ENGINES

Q. How many pounds of steam at 75 lb. per sq. in. pressure (feedwater temperature of 60 deg. F.) can be produced by the exhaust gases of a 750 br. hp. Diesel engine operating at full load?

1. According to Curve I, Fig. 1, the weight of exhaust gas for a 750 br. hp. engine at full load amounts to 7700 lb. per hr. Through the point of intersection of 750 br. hp. and 100 per cent load draw a parallel to the lines of equal waste gas weight and continue it parallel to the corresponding lines in Curve II. 2. Through the point of intersection of 75 lb. per sq. in. and 60 deg. F. feedwater temperature in Curve III, draw a parallel to the lines of equal heat contents and continue it parallel to the corresponding lines in Curve IV. 3. According to Curve I the waste gas temperature $T_E = 680$ deg. F., and according to Curve III the steam temperature $T_S = 307$ deg. F., so the temperature drop from Eq. 3 is: $T = 680 - 307 - 108 = 265$ deg. F. 4. Through the point of intersection of 265 deg. F. and 7700 lb. in Curve II, draw a parallel to the lines of equal heat quantities and continue it parallel to the corresponding lines in Curve IV, until it intersects with the line of the heat content of the steam from Curve III. The point of intersection indicates the quantity of steam produced, which amounts to 400 lb. per hr.

Q. How many pounds of 180 deg. F. hot water (feedwater temperature of 60 deg. F.) can be produced by the exhaust gases of a 750 br. hp. Diesel engine operating at full load?

1. Through the point of intersection of 60 deg. F. feedwater temperature and 180 deg. F. hot water temperature in Curve V, draw a parallel to the lines of equal temperature increase and continue it parallel to the corresponding lines in Curve VI. 2. Temperature decrease of the waste gases from Eq. 4 is: $T = 680 - 180 - 108 = 392$ deg. F. This means that the waste gases would be cooled to $T_E - T = 680 - 392 = 288$ deg. F., which, however, is not advisable because of the danger of corrosion. The highest practical temperature drop would be only $680 - 320$ or 360 deg. F. 3. Through the point of intersection of 360 deg. F. and 7700 lb. per hr. waste gas weight in Curve II, draw a parallel to the lines of equal heat quantities and continue in Curve VI parallel to the corresponding lines, until it intersects with the line of temperature increase of the water, from Curve V. The point of intersection gives the quantity of hot water produced which amounts to 5000 lb. per hr.

(To be concluded)

Eutectic Ice

SALT ICE or frozen sodium chloride brine is now being introduced for use in refrigerated delivery trucks, store cabinets, railroad L. C. L. containers—and in various other places where Dry Ice, mixtures of ice and rock salt, or mechanical refrigeration have been generally utilized. It is available in two forms: small, loose, broken ribbons, and compressed blocks, weighing approximately 30 lb. each.

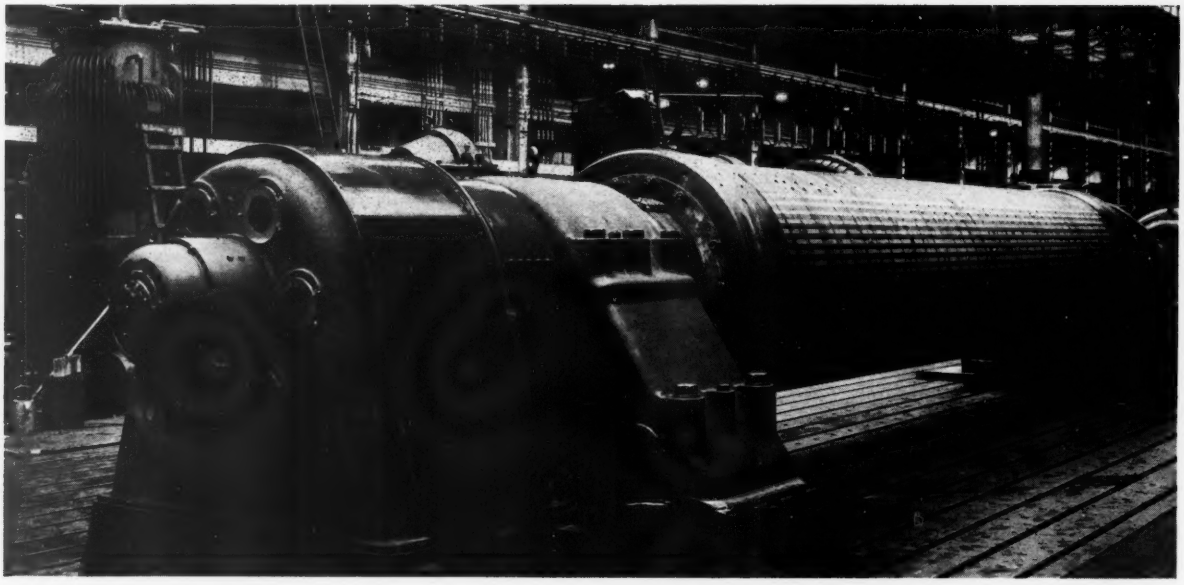
Refrigerating units have been designed for Salt Ice, which, it is claimed, make possible the production of temperatures ranging from 0° F. in ice-cream delivery trucks, even on hot summer days. Uniform temperatures as low as 0° F. up to 36° F. may be maintained by adjustment of conduction surfaces. Besides ice cream, commercial lots of frozen foods, fish, meat and vegetables have been successfully refrigerated with frozen brine.

This refrigerant is made from brine composed of approximately 23% salt and 77% water by weight, the proportions having the lowest possible melting point (—6° F.) for salt and water mixtures. The frozen brine melts at a temperature lower and more uniform than can be obtained with mixtures of salt and crushed ice, and its heat-absorbing capacity is considerably greater. Convenience in use is another advantage; no mixing is necessary. Small quantities are required. No sludge or precipitate remains after melting.

The machine used for the manufacture of Salt Ice is the one which has been in use during the past few years for making fresh-water ice in broken ribbon form.

In the process of manufacture a metal cylinder with calcium chloride brine at —30° F. on the inside rotates slowly in the sodium chloride brine to be frozen. Heat is rapidly extracted through the thin wall of the cylinder. As the ice forms in thin sheets, it is peeled off and dropped into storage bins. Judging by the various installations and practical service tests, the equipment is especially interesting to manufacturers and shippers requiring solid refrigerants in wholesale quantities, and to ice companies in localities where market possibilities justify distribution facilities.—Arthur D. Little, Industrial Bulletin.

CONTRACT has been let for a complete air conditioning system for six of the seven floors of the U. S. Department of Interior Building in Washington, D. C., which will cost approximately $1,000,000. The seventh or top floor of the building, which is naturally the warmest due to the effect of the direct sun on the roof, was air conditioned last year.



The 183,333 kv-a. Generator *at* Richmond Station

By C. M. LAFFOON

Power Engineering Department,
Westinghouse Electric & Mfg. Co.

THE TURBINE GENERATOR unit recently placed in service by the Philadelphia Electric Company at the Richmond Station is of unusual interest not only on account of its large rating but also on account of the fact that it is the only large capacity steam driven generating unit purchased during the past few years. The prime mover element of this generating unit is a tandem compound steam turbine of sufficient capacity to deliver 165,000 kw. output from the generator under normal load conditions and 10 per cent additional kw. output under overload conditions. The electrical end of the unit is a single element generator with a normal rating of 183,333 kv-a., 165,000 kw., 0.9 power factor, 13,800 v., 3 phase, 60 cycles, 1800 r.p.m., and a 10 per cent overload rating for emergency conditions. The new unit is installed in the section of the turbine room originally contempated for a unit approximately one-third the rating. Improvements that have been made during the past 10 yr. in increasing ratings and reducing physical dimensions, together with the fact that the circumstances of the building design made it possible to obtain additional space for the removal of the generator rotor, accounts for the ability to install a unit of so much larger rating.

The generating end of the unit consists of the main generator, a 500 kw., 250 v. main exciter, a 10 kw., 250 v. pilot exciter, and a permanent magnet tachometer. The rotor of the main generator is solidly coupled to the shaft of the low pressure turbine element and the armatures of the exciters are overhung on a shaft which is in turn solidly bolted to the main generator shaft. The proportions and contour lines of the exciters, pedestals, main generator end bells, and housing are coördinated and proportioned so that the general appearance of the assembly is pleasing from the architectural and esthetic standpoint.

Ventilation System

The ventilation system of this generating unit has several new and interesting features. In the first place, the main exciter is totally enclosed and its cooling air is supplied from the ventilating system of the main unit. The cooling air is circulated by propeller type blowers, which are driven at 3500 r.p.m. by squirrel cage induction motors. The design of the ventilation circuit departs from the usual arrangement in that the air coolers are located between the blowers and the units to be cooled. This arrangement reduces the temperature of the inlet air to the generator and main exciter by an amount corresponding to the rise due to the blower losses. An air filter is installed be-

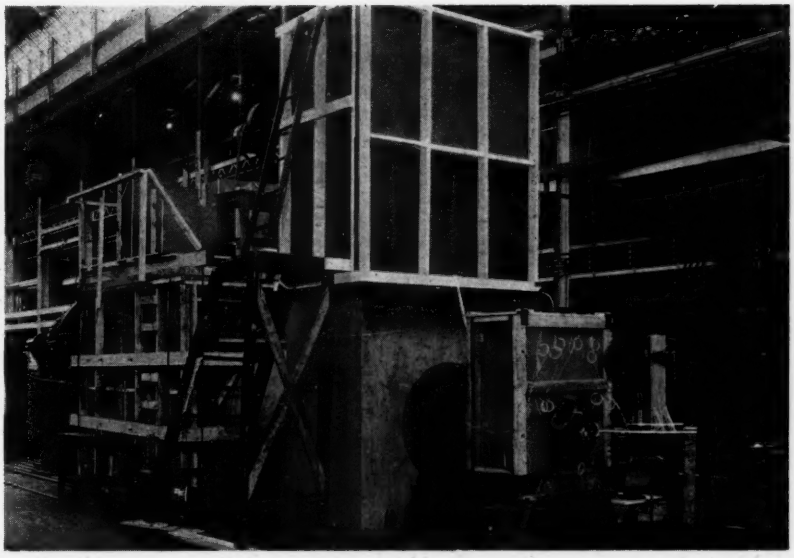


Fig. 1

Propeller Blower Unit set up for test in factory.

A complete recirculating ventilating system was built at the factory so that the output and efficiency of the complete blower unit could be obtained by test. This test system simulated that of the generator as installed at Richmond station

tween the main exciter and the main ventilating system so that all carbon and copper dusts from the commutator and brushes of the exciter are removed before the air re-enters the main channels of the ventilation system. Air ducts are made of heavy sheet steel material to prevent vibration, and special precautions were taken to make tight joints to minimize the leakage of air from and into the system. A make-up filter is also provided to ensure that the make-up air is properly cleaned. This air filter is of ample capacity so that the air velocity through it will be low and the section where the make-up air enters the system will be maintained essentially at atmospheric pressure.

Four propeller type blowers with aero foil section blades are provided and installed in the ventilating circuit. It is believed this is the first application of this type of external blower for turbine generator cooling. Each blower is capable of delivering approximately 57,000 c.f.m. at 10.0 in. water gage and requires a 150 hp. driving motor. Only three blowers are required by the generating unit under full load operating conditions. The additional blower unit is provided for operation as a spare in case of blower failure or it can be operated in parallel with the other units under emergency overload conditions on the generator. The ventilating ducts, dampers and motor control are designed so that one, all, or any combination of blowers can be operated as desired or as the load demands require. The blower blades, which are made from aluminum castings, are dovetailed into a steel supporting hub. The complete runner is consequently relatively light and is overhung on a shaft which is solidly coupled to the driving motor shaft. In order to obtain sufficient design constants and proportions for the blades, intake, discharge guides and diffuser, it was necessary to build a model blower and vary the proportions of the different parts. With the data obtained from tests on the model, the full size blower was accurately designed to meet its output requirements.

A complete recirculating ventilating system simulating that of the generator was built at the manufacturer's plant so that the output and efficiency performance of a completed blower unit could be obtained by test. The static pressure developed by the blower decreases rapidly and continuously with increasing volume of air delivered. This drooping type of pressure-volume characteristic is essential and necessary for satisfactory and stable performance of blower units operating in parallel. The efficiency performance of the blower and driving motor was obtained by measuring the electrical input to the driving motor, motor losses, and blower output in cubic feet per minute at different pressures. The motor losses were obtained by the calorimeter method.

When delivering 57,000 c.f.m. against a back pressure of 10 in. of water, the overall efficiency of the blower, including the losses of the driving motor, was approximately 72 per cent, which is considered an outstanding performance for any type of blower.

Main Generating Unit

Reliability of performance of super-capacity generating units is of such paramount importance that conservatism was considered the basic feature in the design of the unit. Unusual consideration was given to the electrical, mechanical, and thermal design problems so that maximum reliability and stability of performance would be obtained and still keep the resultant product within economic weight and dimension limitations.

The contract specifications required the main generator to have a short-circuit ratio of not less than unity at the full load 183,333 kv-a., 0.9 P.F. rating. This is the highest short-circuit ratio obtained for any turbine generataor of comparable size which has been built up to the present time. The overall length of the generator from the face of the coupling on the turbine end to the end of the housing of the tachometer is approximately 43½ ft. and the overall width 17 ft. The total weight of the generator, exclusive of air ducts, is 783,000 lb. or 4.27 lb. per kv-a. of rating. The weight of the rotor is 250,000 lb. and its dimensions are such that it could be built complete at the works

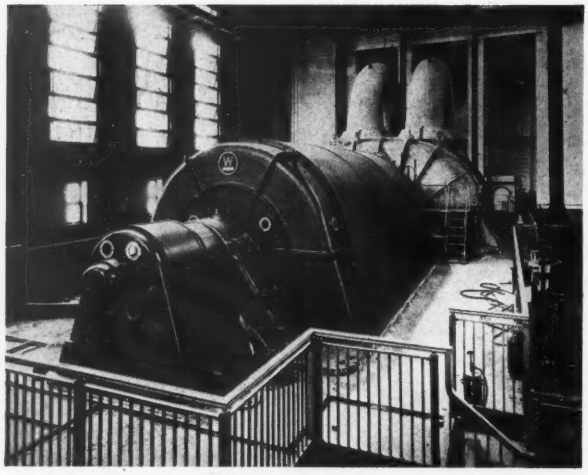


Fig. 2. The 183,333 kv-a. turbine generator as installed at Richmond Station

and shipped to the destination. The dimensions and weight of the complete stator were such that it had to be assembled at the customer's plant. The stator frame was split vertically in three transverse sections to keep the parts within shipping dimension limitations. After reaching destination, the frame sections were bolted together and the stator core built as a complete unit without any core splits.

The stator core was built with the lowest loss silicon sheet steel commercially obtainable. One of the most important requisites for satisfactory stator core performance is that the core remain sufficiently tight under all operating conditions so that there will be no movement or vibration of individual laminations or groups of laminations. Sheet steel of high silicon content is more susceptible to warping and buckling than steels of lower percentage silicon, when punched into segments. The use of high silicon steel for large capacity machines with long cores very materially increased the difficulty of building the cores tight. In this particular case, the aid and coöperation of the steel manufacturers was enlisted. As a result, the engineers of the American Rolling Mill Co. undertook the production of sheet steel of high silicon content which, when punched into segments and annealed to relieve punching strains, would be free of bends and buckles, and would conform to specific standards for flatness. By closely coöperating with the steel company and exercising more exacting supervision of our own punching and annealing processes, the segmental laminations actually obtained and used in the construction of the stator core of this machine were comparable in flatness with the best punchings previously obtained for steel of much lower silicon content.

Stator Winding

Contract specifications required that the main generator have two 13,800 v. separate stator windings capable of being operated independently within definite load limits. The requirement of 13,800 v. for the stator winding imposed no handicaps in the design of the generator. For this particular rating, power factor, short-circuit ratio, the slot combinations and possible winding combinations were such that 13,800 v. proved to be the most economic voltage from the standpoints of dimensions and performance economy. A double winding of the alternate groups of slots type was used on account of the fact that its reactance coefficients are not appreciably affected by saturation under heavy current conditions, and in addition it can be operated with a reasonable amount between the two windings. With this type of winding, each phase group is divided into two equal or approximately equal parts and the parts connected alternately in series for each pair or multiple of pairs of poles.

The stator coils were made in halves to facilitate manufacture, handling, assembling in the core, and replacement in case of repair. Each single turn coil consists of rectangularly shaped insulated strands arranged two wide and a large number depthwise. The strands are completely transposed widthwise and depthwise throughout the entire length of the coil side located in the stator slots to reduce eddy current losses in the copper due to the stator leakage flux across the slots. The strands are transposed in groups at the connection between coils to reduce the eddy currents in the conductors due to magnetic fluxes in the end zones.

Rotor

The rotor is of the multiple element design in which high quality forgings are used for the shaft ends, end heads, and body discs. The end heads and body discs are rigidly clamped together by means of four pole body bolts and one large central bolt. The shaft ends in turn are spigotted in the end heads and are anchored by means of a continuous circle of coupling bolts. The torque between the shaft ends and end heads is transmitted by accurately fitted radial keys.

In the construction of the unit, careful consideration was given to the material used for and general proportions of all structural parts, such as stator end plates, fingers, ventilating duct spacers, and through bolts to keep the temperatures and losses in these parts to minimum values. An effort was made in the design of the generating unit and its auxiliaries to obtain low losses under all operating loads.

FIG. 3

Propeller blower unit

Four propeller blowers of this aero foil section blade type are installed in the ventilating circuit. Each blower is capable of delivering approximately 57,000 c. f. m. at 10. in water, gage, and requires a 150 hp. driving motor

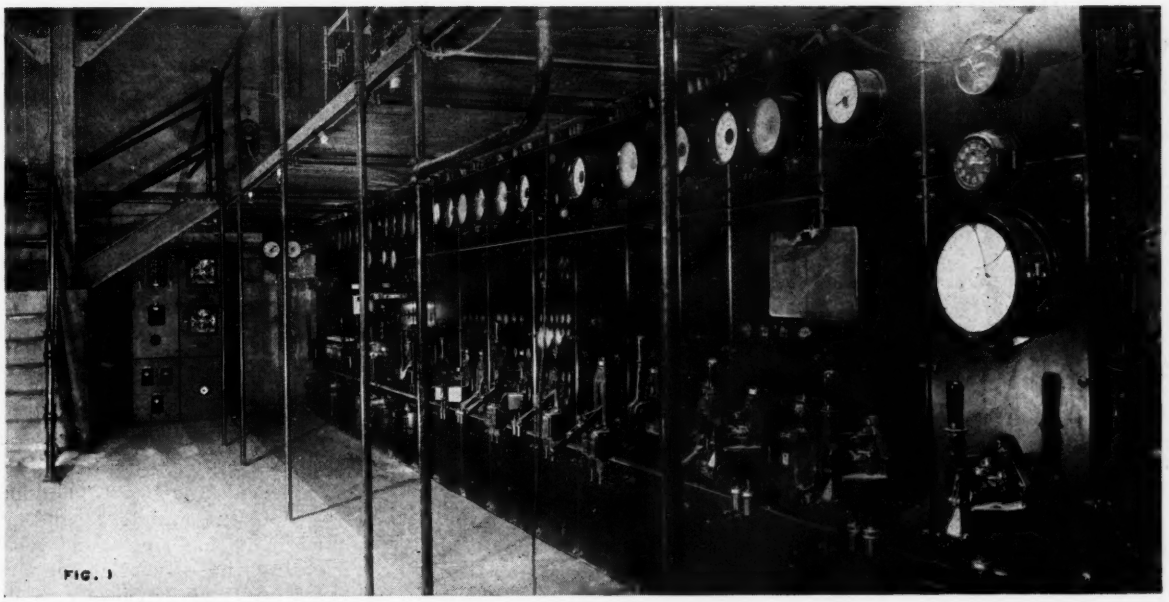


FIG. 1

Automatic Synchronizing Eliminates "Guesswork" in Switching

By
E. H. STIVENDER
Electrical Engineer
Switchgear Division, Allis-Chalmers Mfg. Co.

AT KOSMOSDALE, Kentucky, about 15 miles southwest of Louisville, is located the property of the Kosmos Portland Cement Company. Under progressive and efficient management, this company has not only successfully weathered the depression but has expanded and improved its facilities each year.

The 1934 program included the modernization of the power plant equipment. Up to this time, the power plant contained two steam turbine units; one of 1500 kw., 80 per cent P. F. installed in 1913 and and one of 2500 kw., 80 per cent P. F. installed in 1925. The switchboard was of the manually operated type, that is, lever operated circuit breakers with knife switches.

Improvements called for replacement of the 1500 kw. turbine with a new one of modern design. The 1500 kw. generator stator and rotor were completely rewound at the factory, K-Fin type air coolers installed and the unit re-rated at 2000 kw., 80 per cent P. F. The new switchboard equipment included "Synchro-Operator," two rocking contact voltage regulators and a temperature indicator with twelve-point transfer switch to read on both generators. This equipment, with three small auxiliary transfer relays for the Synchro-Operator, are mounted on the two 20-in. panels at the end of the switchboard as shown in Fig. 1. There were installed a solenoid operating mechanism for one of the old manual circuit breakers and a complete new 4000 amp. solenoid operated oil circuit breaker. Control switches, indicating lamps and two push buttons for mounting on the existing generator panels on the main switchboard were also provided. The push buttons are for connecting the Synchro-Operator in circuit.

While the Synchro-Operator may be mounted on a swinging panel instead of the usual synchronism indicator, in view of space required for the temperature indicator and voltage regulators, it was decided to mount this equipment on one of the two switchboard panels at right angles to the main board. This also allowed space for the three auxiliary relays required for the Synchro-Operator where pushbutton control instead of synchronizing switches is used. These relays are at the bottom of the panel, as in Fig. 1. The arrangement allowed nearly all of the new switchboard wiring to be done at the factory, the only control connections required on the job being those of the circuit breakers, instrument transformers and push buttons.

The object of providing automotic control was to eliminate uncertainties in switching and to provide constant voltage, impossible with manual operation.

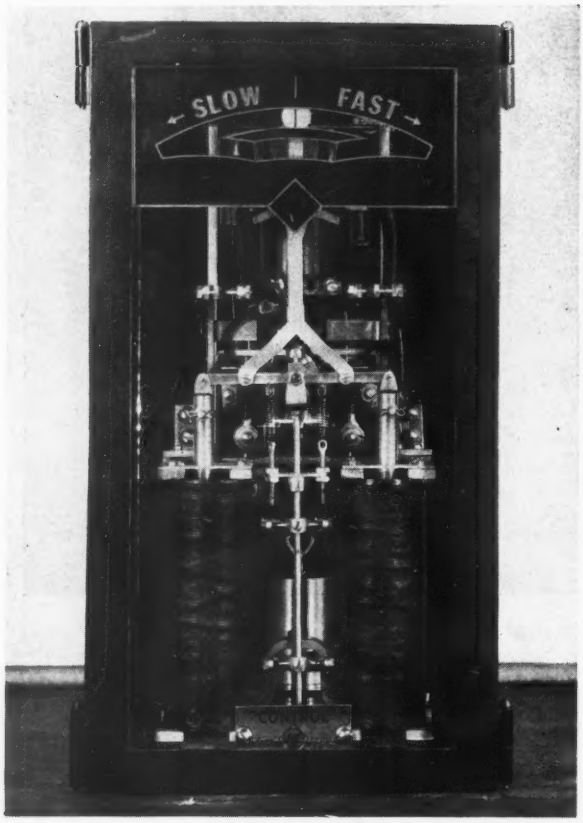


Fig. 2. Synchro-operator for automatic speed matching and synchronizing

As is well known, manual synchronizing consists of guess-work; high grade manual synchronizing requiring an operator of reliability and experience who can correctly estimate the proper instant to begin closure of the circuit breaker. This plant was among many which have experienced the adverse results of "bumping" generators, such as the loosening of armature coils in the slots, shock on the prime mover and loss in efficiency of all power and lighting equipment in general, besides the danger of a breakdown of some vital piece of equipment as long as this procedure is allowed to continue. Proper automatic synchronizing is much faster and accurate than manual operation. It correctly closes the circuit breaker at the first favorable moment.

Operation

By the use of a Synchro-Operator, the only manual operation necessary to properly connect a machine to the bus is the starting up of the turbine, pushing a button (to connect the Synchro-Operator in service) and loading up the machine to the desired value after the circuit breaker has been automatically closed. The push buttons may be mounted near the governors so as to eliminate any need of going to the switchboard or they may be mounted on the respective generator panels. At the Kosmos plant, the push buttons are on the generator panels.

After pressing the button, the Synchro-Operator automatically regulates the speed of the prime mover, indicates "fast" and "slow" and phase angles, as does a synchroscope, and automatically closes the circuit breaker at the exact point of synchronism, correctly anticipating for the fraction of a second required for the circuit breaker to close after the control circuit is energized. This anticipation of the proper instant for the circuit breaker to close is accomplished by making the main contacts of the Synchro-Operator close at a greater advance phase angle for a greater frequency difference between generator and bus, that is for frequency differences within the safe value for paralleling; above this value, the control circuit cannot be closed. After an operation, the Synchro-Operator is automatically disconnected from circuit.

Automatic Equipment

Figure 2 shows a close-up view of the Synchro-Operator. A short description will be given here. Its properties are such as to provide the three functions required in paralleling generators, that is, frequency matching, correctly indicating phase angles and relative speeds and synchronizing, that is, closing the circuit breaker at the exact point of synchronism, all within one device measuring 7 in. wide by 7 in. deep by 13¼ in. high. Being an integral combination of all three devices, it has entered the field under a new name. There is an auxiliary box mounted in the rear, as shown in the rear view Fig. 3, at the upper right hand corner of the panel. The center of the panel accommodates the temperature indicator. Figure 3 illustrates the extreme simplicity of adding automatic control to an installation when a Synchro-Operator is

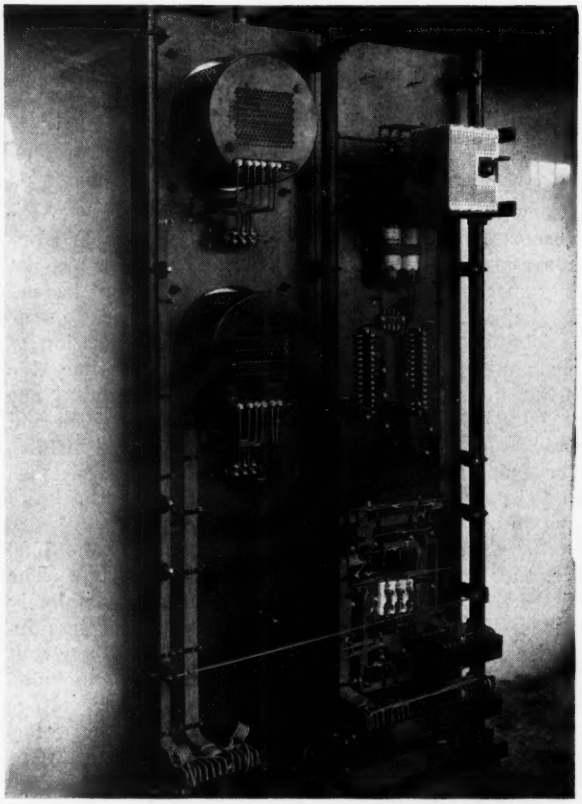


Fig. 3. Rear view of Automatic Control Switchboard for the Kosmos Portland Cement Co.

used. The panel on the left accommodates the two rocking contact voltage regulators.

There are two single pole knife switches mounted beside the Synchro-Operator. One of the switches is for removing the frequency matching operation from service and one is for disconnecting the automatic synchronizing. By opening these two switches, all automatic control is rendered inoperative and the device is still available for use as an accurate synchroscope, for cases where manual operation is desired. During automatic operation the indicator offers a visible check on the action.

Referring to Fig. 2, the tip of the pointer moves behind a slotted dial, following the path as outlined. The center upper position is the point of synchronism; the center lower is 180 deg. out of synchronism. A movement of the tip of the pointer in a clockwise direction around the periphery of the dial indicates that the incoming machine is faster than the running machine, while a counterclockwise movement indicates that it is slower. The design of this indicating element provides a measure of the phase angle for almost any position in the 360 deg. slip cycle. The pointer does not simply vibrate back and forth but has a different position for nearly any phase angle.

Space prohibits a complete description of the Synchro-Operator, which operates on entirely different principles from other synchronizing devices, but a summary of the distinctive features which use of these principles have allowed are given below:

1. Accurate operation, anticipating for the inherent time lag of the circuit breaker by initiating closure of the circuit breaker at an advance phase angle proportional to the frequency difference.
2. Closure of the circuit breaker at the first favorable moment, thereby reducing the time required to put a machine on the line.
3. Safety, adequate insurance being made against failure of any part to function properly.
4. Simplicity of design, compactness and neatness, making it available for a prominent place on the switchboard, such as on a swinging bracket.
5. A minimum of auxiliary equipment. A Synchro-Operator may be switched in and out of circuit by switchboard synchronizing switches, no other equipment being necessary.
6. Ruggedness; it is a solenoid operated device of high torque, permitting strong mechanical design to be used. No equipment subject to shock or requiring periodic replacement are employed.
7. Three primary functions; the three functions required for the paralleling of generators are incorporated in the one integral assembly. None of the operations is given by a secondary attachment.
8. Only one Synchro-Operator is required for any number of generators.
9. Standard electrically operated governor and circuit breaker control are adapted to its use. Any plant which now has governor control from the switchboard and electrically operated circuit breakers needs practically no additional equipment for the installation of a Synchro-Operator.
10. Automatic anti-hunting of the governor. The governor speed setting is actuated by impulses and not continuous movement. These impulses become farther apart as synchronous speed is approached. The duration of the impulses may be readily set for any governor or governors. (Note the adjustment knob on the auxiliary box, Fig. 4.)

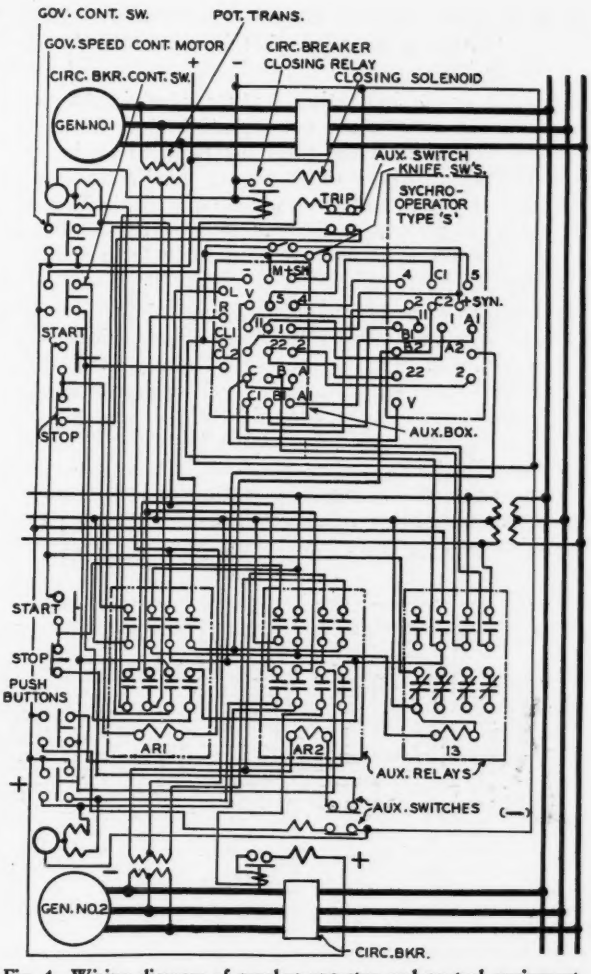


Fig. 4. Wiring diagram of synchro-operator and control equipment at Kosmos Portland Cement Co.

11. The governor is never actuated until the point of synchronism has been passed, hence the governor speed setting will never be changing just before or after the circuit breaker is closed.
12. When settings are required for a particular circuit breaker, it is necessary to make only one adjustment which can quickly and easily be made by a person unfamiliar with this class of apparatus. This adjustment compensates for the time required for closure of the circuit breaker.
13. Appreciable voltage difference between sources does not impair its accuracy. The device does not depend upon zero voltage difference for correct operation.
14. Low energy consumption. Ordinary potential transformers are sufficient.
15. No special connections of potential transformers. The device may, in nearly all cases, be added to an installation where transformers are already installed for metering purposes, no additional transformers being necessary.

16. A Synchro-Operator may be used where no control battery is installed, that is, where A. C. control is being used.
17. Owing to its indicating feature, electrically controlled governors are not essential, since an operator may control the speed by hand according to observed readings until proper conditions exist, when the circuit breaker will be automatically and accurately closed. This eliminates the need of an operator running back and forth from switchboard to governors.
18. Remote indications of "fast" and "slow" may be sent over only two wires by the device, when such are desired. This is a useful property for installations such as automatic reclosing substations where the sources on each side of a circuit breaker may become out of synchronism; "fast" and "slow" signals can be sent over a telephone line to an attended generating station so that the systems can be brought into synchronism and the substation breaker automatically closed by the Synchro-Operator, no supervisory control being needed.
19. It is not simply a contact-making synchroscope, but a device especially designed with the proper torque requirements in view to fill an individual need in the industry.

Installation

Since most readers will be familiar with the installation of such equipment as rocking contact voltage regulators and circuit breakers, only the wiring of the automatic switching equipment will be taken up here.

Fig. 4 is a wiring diagram of the Synchro-Operator and auxiliary equipment installed at the Kosmos Portland Cement Company power house, showing the auxiliary relays, push buttons, control switches, etc. It will be noted that three phase potential transformers were used on both the bus and the generator sides. This is one of the connections possible where the transformers are available but for installations where only single phase potential is available on one side, identically the same operation can be obtained without requiring the installation of additional step-down transformers. In other words, a Synchro-Operator operates with either three phase transformers on both sides or single phase on one side and three phase on the other —it makes no difference which side is single phase.

As stated before, where synchronizing switches are used, no auxiliary relays and push buttons are necessary. The push button control illustrated in Fig. 4 includes both a "start" and a "stop" button; the "stop" button being for use in case it is desired to prevent closure of the circuit breaker after the start button has been pressed. In other words, the "stop" button is only for occasional use, the Synchro-Operator being normally disconnected from the line automatically by action of an auxilary switch on the circuit breaker after closure.

Test Results

The chart, Fig. 5, was obtained by connecting a graphic voltmeter across potential transformers, as shown in the same illustration. Minimum voltage on the chart indicates zero phase angle. Note will be taken that there was one operation of the Synchro-Operator, as marked on the chart. This chart was

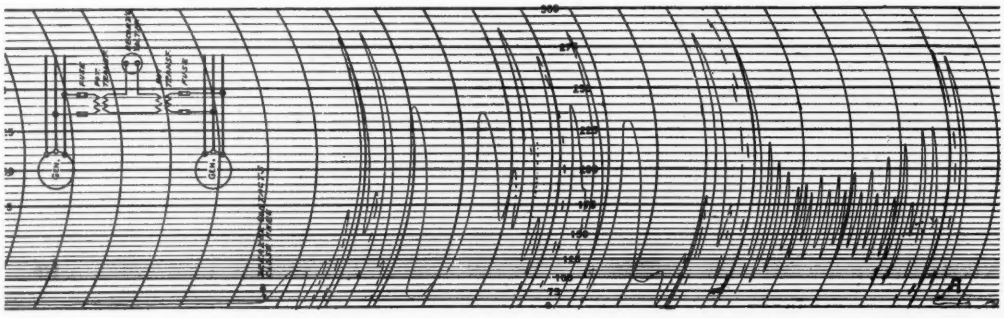


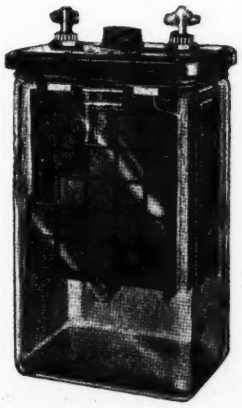
Fig. 5. Voltmeter chart showing operation of synchro-operator during frequency matching and synchronizing of two steam turbine units, using a 4000 ampere oil circuit breaker

traveling at high speed. At the point marked "A" the Synchro-Operator was connected in circuit at a frequency difference. This difference was automatically reduced until the point of closure of the circuit breaker, where the curve remains at minimum. By observation, the accuracy of synchronizing is apparent, since the circuit breaker is shown to have closed at the exact point of synchronism.

This chart was made in the power house of the Kosmos Portland Cement Company. It is interesting to make tests like this during manual synchronizing. The time required to synchronize at Kosmos averages less than one half minute.

Occasionally during a spring house cleaning some article that has been long forgotten and sorely needed will be unearthed from the dust in the attic corner. A company, according to Au Sable News, had a similar experience recently. In starting a job on a newly acquired property, an inventory was taken of equipment on hand. Among other things found was a crated oil circuit breaker, which, though not exactly new, had never been used. Growing up through the crate was a tree, two inches in diameter at the butt and spreading its useful branches some feet above the top of the crate.

STORAGE BATTERY CHARGING*



Part I.

By

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Philadelphia, Pa.

WHILE THE REACTIONS WHICH take place during the charge and discharge of the lead acid storage cell are not in all respects fully understood and have been the subject of some controversy, the fundamental facts, insofar as they affect the practical industrial application and control of the storage battery, are well established and may be recapitulated briefly here as a foundation for the discussion of storage battery charging to follow.

There appears to be no reason for questioning the so-called double sulphate theory which is expressed in the following equation:

$$PbO_2 + 2\,H_2SO_4 + Pb \rightleftarrows PbSO_4 + 2\,H_2O + PbSO_4$$

the left hand member representing the charged condition and the right hand member the discharged condition. This equation shows that during discharge a part of the sulphuric acid in the electrolyte is combined with the active material, forming lead sulphate in both positive and negative plates, while a corresponding amount of water is produced, giving rise to the well known reduction in the specific gravity of the electrolyte during the discharge and the corresponding increase during the charge.

Up to this point the charging of a storage battery appears to be a simple matter but there are other phenomena and conditions which develop which are not indicated by this fundamental formula.

*Abstract of a paper presented at the Summer Convention of the American Institute of Electrical Engineers, Ithaca, N. Y., June, 1935.

Acid Concentration in the Plates

Further study shows that during the charge, strong sulphuric acid is formed in the active material of both plates. This gives rise to a higher concentration of acid in the pores of the plates than that of the free electrolyte outside on account of the time required for diffusion. Diffusion occurs more readily near the surface so that the acid concentration is greater in the more inaccessible parts, producing higher counter electromotive force to oppose the charging current.

These inaccessible regions charge more slowly, therefore, and are the last to be fully charged. The gradual rise of acid concentration produces a gradual rise of voltage. The effect of high acid concentration in retarding the charge is more marked in the case of the negative plate and if the acid concentration is sufficiently high it is impossible to reduce the sulphate to spongy lead.

Gassing.

There are other reactions besides those involved in the conversion of lead sulphate into lead peroxide. These are merely the preferential reactions and take place so long as there is sufficient sulphated active material accessible to absorb the current. Whenever the charging current exceeds this value, the excess, which cannot be used for charging the active material, causes decomposition of the water of the electrolyte into hydrogen and oxygen which are released as bubbles of gas—the hydrogen at the negative plate and the oxygen

at the positive—and the familiar phenomenon of gassing appears. A higher voltage is required to release gas than to charge the active material so the beginning of active gassing is indicated by a comparatively rapid rise of voltage at the cell terminals. Figure 1 shows a typical charge curve and illustrates the phenomena just referred to. This chart also shows the specific gravity curve and the rate of gas evolution. The more rapid rise of the specific gravity curve after gassing begins is the effect of the gas bubbles in forcing out the heavier electrolyte from the pores of the plates as well as the starting up of heavier electrolyte which may have settled to the bottom of the cell.

Faraday's Law

According to Faraday's law a given amount of current passing through an electrolytic cell can produce only a definite amount of electrochemical reaction. Hence, that part of the current which produces gas by decomposing the water in the electrolyte cannot have any effect in charging the active material. This applies separately to the positives and the negatives—that is, the same current which produces gas (oxygen) at the positive plate after that plate is fully charged may still be charging the active material of the negative plate if that plate is not fully charged, but any part of the charging current which produces gas at both plates is absolutely wasted as far as charging the active material is concerned.

The accompanying diagram, Fig. 2, illustrates this fact, showing the results of two charging tests following a 10 per cent discharge, in one of which the cell was charged at constant current and in the other at constant voltage. The rate of evolution of gas was measured in each case and converted into ampere-hours by well-known electrochemical constants, and plotted in the form of curves. The ampere-hours actually put into the cell are shown in dotted lines, and from this was subtracted the ampere-hour equivalent of the gas evolution, leaving the net ampere-hours used for charging the active material, indicated by the curves marked "state of charge." It will be noted that the constant voltage method, at 2.25 volts, charged the cell almost as rapidly as the constant current method, and much more efficiently. The next curve, Fig. 3, shows a similar test following a 20 per cent discharge.

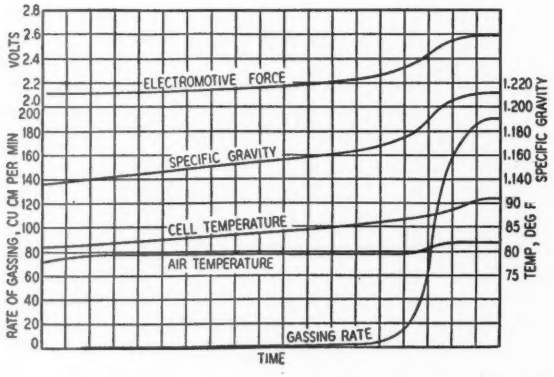


Fig. 1. Typical curves of charge voltage, specific gravity, and gassing. Charge at 8 hr. discharge rate following 8 hr. discharge

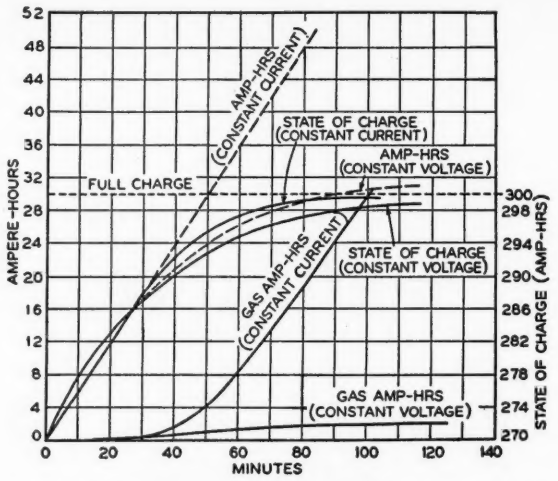


Fig. 2. Constant current versus constant voltage charge following one hour discharge at 10 hr. rate (30 amp.)

Constant current = 36 amp.
Constant voltage = 2.25 v. per cell.
Constant temperature = 26.5 deg. C.

Heating Effects

The heat produced in a cell during the charging period is due to three causes: First, there is the ordinary resistance loss (I^2R) determined by the current and the true ohmic resistance of the cell. The second cause of heat generation is that due to the sum of the normal chemical reactions, also the mingling of sulphuric acid produced by the charging current with the water of the electrolyte producing some heat. These heating effects are small and practically negligible under ordinary operating conditions.

Toward the end of charge another quantity of heat is developed, the source of which is somewhat obscure. The total energy represented by the product of the charging current by the final charge voltage is appreciably greater than the sum of the resistance loss and the electrochemical energy involved in the decomposition of the water of the electrolyte into oxygen and

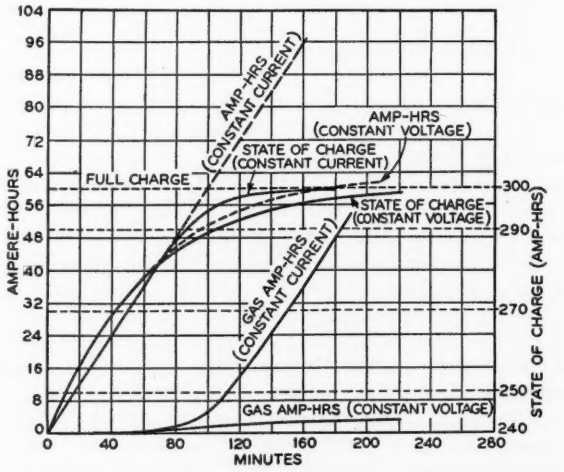


Fig. 3. Constant current versus constant voltage charge following 2 hr. discharge at 10 hr. rate (30 amp.)

Constant current = 36 amp.
Constant voltage = 2.25 v. per cell.
Constant temperature = 25 deg. C.

hydrogen. This difference appears in the form of heat. One of the theories advanced to account for this is the production of ozone at the positive plate as an intermediate reaction, which is immediately converted into oxygen with the development of heat. This theory is plausible, as the familiar odor of ozone is often noted. Another theory involves the formation of atomic hydrogen at the negative plate. It has thus far been impossible to establish these theories quantitatively.

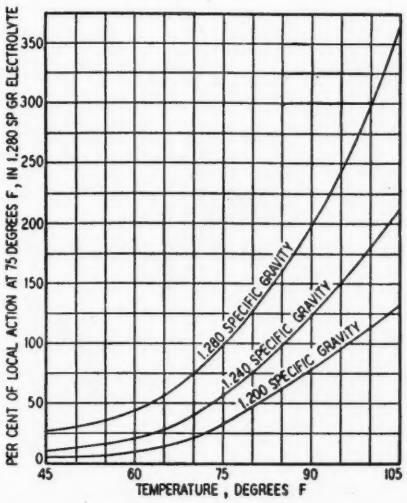


Fig. 4. Variation of local action with temperature and specific gravity of electrolyte

However, the rapid rise of temperature after gassing begins is a well-known fact.

Stratification

Stratification of the electrolyte is another phenomenon which may sometimes be observed. The strong acid which is produced in the pores of the plates during the charging period has a tendency to settle in the region below the plates but as a rule convection currents produced by the gas bubbles during the later stages of the charge prevents any considerable degree of stratification. In stationary cells the electrolyte in the dead space from the bottom of the cell to a point about ¾ in. to 1 in. below the bottoms of the plates will usually show a slightly higher density than that of the active electrolyte above this level. The only result of stratification is a slight weakness of the active electrolyte which tends to reduce the available capacity. This phenomenon does not occur in batteries maintained by floating or trickle-charging and any mechanical vibration to which a battery is subjected tends to minimize it.

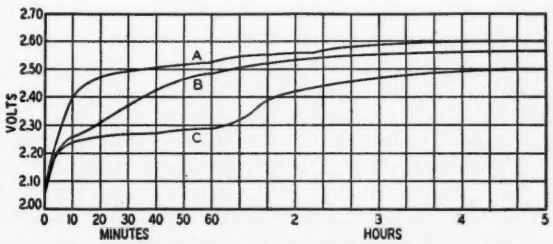


Fig. 5. Effect of local action on charge voltage. Three cells charged in series after 5 days stand on open circuit

Effect of Local Action

It is well recognized that a certain amount of local action or self-discharge is taking place continually in a storage battery cell. By far the greater amount of this local action occurs in the negative plate. Local action occurs continuously whether the battery is charging or discharging or standing on open circuit. It increases rapidly with increase of temperature and with increase in the specific gravity of the electrolyte. The accompanying curves, Fig. 4, illustrates these effects. Local action is evidenced by the gassing of the negative plates when standing on open circuits. It results in the gradual sulphation of the negative material and the consequent falling off of the specific gravity of the electrolyte. Cells which have been in service for a considerable length of time will usually exhibit some increase in the amount of local action. There also appears to be a quite definite relation between the amount of local action and the final voltage of the cell at the end of the discharge. The charge curves, Fig. 5, of 3 cells will illustrate this.

The 3 cells had been fully charged and then stood on open circuits for 5 days. They were then charged in series, and the charge voltage readings plotted as shown. The difference in the amount of local action is clearly indicated. In cell A the local action is comparatively little, the voltage rising rapidly to the gassing point. Cell B shows more local action, the rise in voltage being slower and the final voltage lower. In cell C the local action is pronounced, the final maximum voltage being reached only after 4 hours' charging and being still lower than that of the other two. The first sharp rise of voltage in curve C evidently corresponds to the charging of the positive plate, while the second rise is due to the negative plate.

Efficiency

The efficiency of a storage battery, that is the ratio of the output to the input, may be divided into two parts, namely voltage efficiency and ampere-hour efficiency. The product (providing the charging rate is constant) being the energy or watt-hour efficiency. The voltage efficiency depends upon the difference between the charge voltage and the discharge voltage. The principal factor in this difference being the rates of charge and discharge. Obviously, at higher rates the discharge voltage will be lower and the charge voltage higher. The ampere-hour efficiency depends upon two factors, first the loss due to local action and second, that due to the gassing during the charge. the local action loss is negligible compared to the work well as with the temperature. The loss due to gassing depends entirely upon the charging conditions. If The local action loss varies with the elapsed time as done, as is the case where the cycle is short and includes a considerable amount of discharge, the ampere-hour efficiency may be brought very close to 100 per cent by careful control of the charging rate below the gassing point.

[Editor's Note: This is the first part of a paper presented by Mr. Woodbridge at the summer convention of the American Institute of Electrical Engineers, June 24-28. The remaining portions of the paper will be abstracted in subsequent issues.]

Combustion Control

Part VIII. Balanced Draft Control of The Engineer Co. Steam Pressure and Furnace Draft Regulators for Stokers, Pulverized Coal, Oil or Gas Fired Boilers

BALANCED DRAFT is a trade name used to designate the apparatus for, and the operating principles of, the combustion control of The Engineer Co. and, as such, has no relation to the physical state of the furnace as reflected by the pressures inside and outside of the furnace walls. Such a balance, desirable in the days of hand firing, is not maintained in modern forced draft stoker plants. Instead, a slight draft is carried and the exact value for best operation should be determined by test as it varies with the individual boiler unit.

As applied to stokers, the system is based on the maintenance of constant furnace pressure and the coordination of fuel feed, air supply and the removal of the gases of combustion so that a change in any one of the three will result in an automatic correction of one or both of the others. With the fuel in the furnaces as with stoker firing, the air supply controls the rate of combustion or heat liberation. The gases of combustion are proportional to the rate of combustion and with constant furnace conditions the position of the outlet damper is a measure of the rate of flow so that the position of the damper is taken as a measure of the rate of combustion and the fuel feed regulated in accordance with it.

A typical installation is shown by Fig. 1. In general, the action is as described below. If there is an increase in the load on the plant, there will be a pressure drop in the steam header. The steam regulator will then gradually speed up the fan, force more air

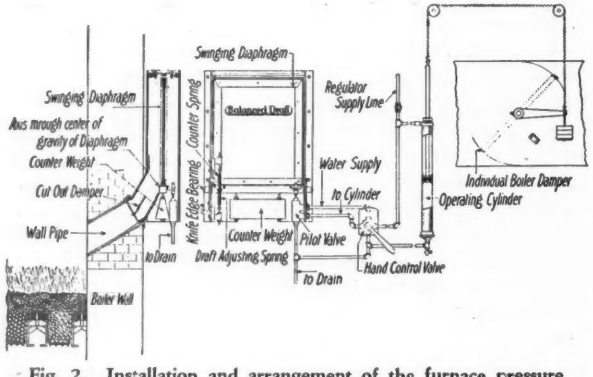


Fig. 2. Installation and arrangement of the furnace pressure regulator

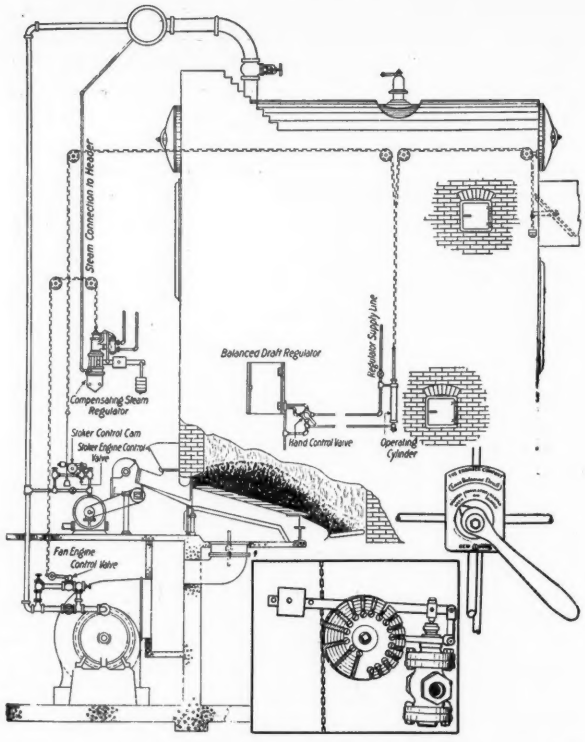


Fig. 1. A typical installation of Enco Balanced Draft Control on an underfeed stoker fired boiler. Inserts show the construction of the adjustable cam on the stoker drive steam valve and the cylinder control valve for shifting from automatic to manual control

through the fuel bed and increase the rate of combustion. This will produce more gas and tend to decrease the draft in the furnace chamber. The furnace pressure regulator will immediately increase the damper opening sufficient to remove the gases at the new rate and maintain the pre-determined draft. At the same time the stoker control cam will be turned to a new position and the correct amount of fuel to support the increased rate of combustion will be fed.

Details of construction and operation of the pressure regulator are shown by Fig. 3. The regulator action is compensated through a range of 5 lb., that is, a 5 lb. pressure change is required for a full stroke of the operating piston. Furnace draft is maintained constant within 0.02 in. of water column, by means of a furnace pressure regulator of the type shown by Fig. 2. A swinging diaphragm is drawn inward by the furnace suction and outward by a spring which is adjusted to maintain whatever draft has been determined by test as most efficient. The diaphragm moves a pilot valve connecting to an operating cylinder which applies a correction to the damper, increasing or decreasing the opening to maintain the furnace suction at the valve for which the regulator is set by the spring adjustment.

An increase of damper opening results from increased combustion, producing more gas, or, from a too thin fuel bed, admitting excess air. In either case, more fuel is required. A decrease of damper opening results from decreased combustion, producing less gas, or, an increase of fuel bed resistance which reduces the rate of combustion and the resulting gas. In either case, less fuel is required.

Stoker speed is controlled in accordance with the

damper opening by the same operating cylinder by means of an adjustable control cam shown in the small detail drawing in Fig. 1. The adjustable cam is introduced between the damper and the stoker engine valve to permit adjustment of the relation between damper opening and stoker engine speed. By means of it, any desired speed of the stoker engine, to correspond with any given movement of the damper and consequent change of damper opening, can be insured. Adjustment of the cam can be made to secure automatic maintenance of a light fuel bed for low rates of combustion, a heavy fuel bed for high rates of combustion, or, if preferred, a uniform fuel bed for all rates of combustion.

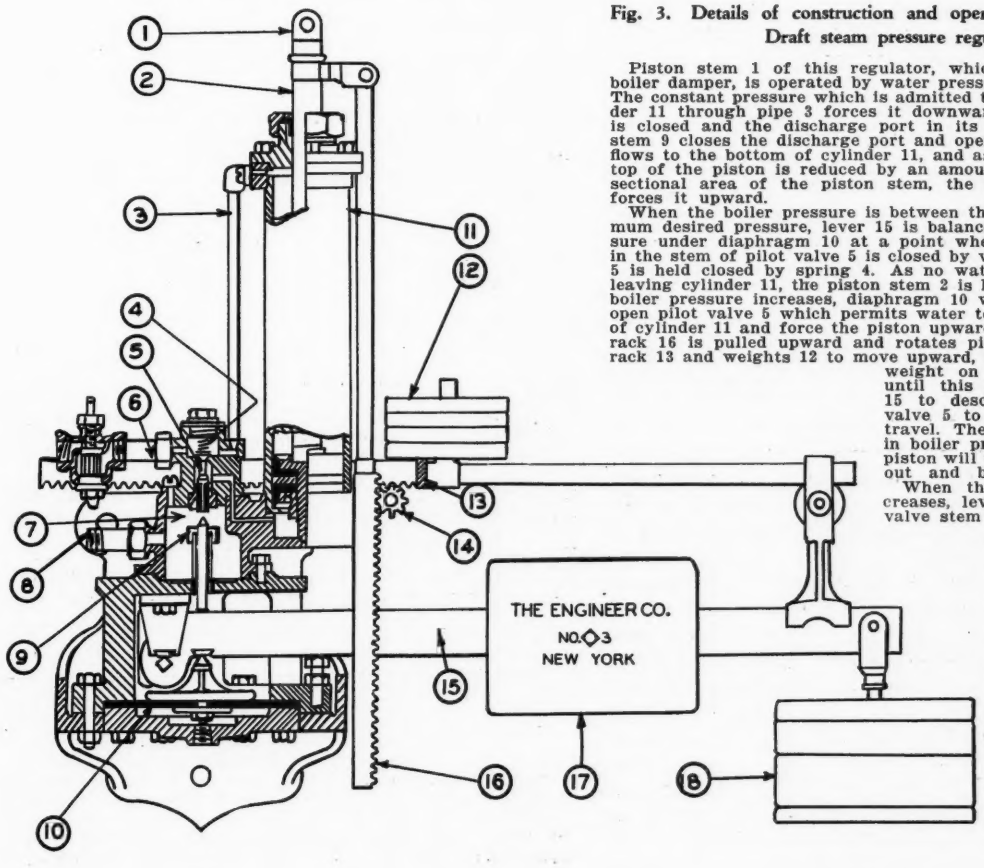


Fig. 3. Details of construction and operation of the Balanced Draft steam pressure regulator

Piston stem 1 of this regulator, which is attached to the boiler damper, is operated by water pressure in either direction. The constant pressure which is admitted to the top of the cylinder 11 through pipe 3 forces it downward when pilot valve 5 is closed and the discharge port in its stem is open. When stem 9 closes the discharge port and opens pilot valve 5 water flows to the bottom of cylinder 11, and as the effective area on top of the piston is reduced by an amount equal to the cross-sectional area of the piston stem, the water pressure below forces it upward.

When the boiler pressure is between the minimum and maximum desired pressure, lever 15 is balanced by the steam pressure under diaphragm 10 at a point where the discharge port in the stem of pilot valve 5 is closed by valve stem 9 and valve 5 is held closed by spring 4. As no water is now entering or leaving cylinder 11, the piston stem 2 is held stationary. If the boiler pressure increases, diaphragm 10 will raise lever 15 and open pilot valve 5 which permits water to flow into the bottom of cylinder 11 and force the piston upward. As the piston rises, rack 16 is pulled upward and rotates pinion 14, which causes rack 13 and weights 12 to move upward, thereby increasing the weight on lever 15 by degrees until this increase causes lever 15 to descend and closes pilot valve 5 to arrest further piston travel. The greater the increase in boiler pressure the higher the piston will travel to move weights out and bring lever 15 down.

When the boiler pressure decreases, lever 15 will lower and valve stem 9 will fall, the water will then flow from the bottom of cylinder 11 through the pilot valve discharge port to discharge chamber 7 and out of drain 8 and permit the pressure on top of the piston to force it downward by which operation the weight bearing upon lever 15 is gradually diminished. This enables lever 15 to rise again, close the pilot valve discharge port and hold the piston stationary in the position into which it had been moved.

In the case of more than one boiler, a single pressure regulator may be used to control the air supply to all boilers, but each boiler has its own furnace pressure regulator. Coördination of the equipment in this case is shown by the action when a boiler is taken off the line while the steam load remains unchanged. If there is no change in header pressure, the fan speed remains unchanged, but since the same volume of air is supplied to fewer boilers, each receives more air and the rate of combustion increases to make up for the loss of the boiler cut out. In this case, the action of the furnace pressure regulators (which depends upon the amount of gas produced in the furnaces), increases the damper openings, and the stoker control increases the fuel, in step with the rate of combustion.

Loads on the different boilers tend to be evened automatically due to the action of the furnace pressure regulator. The thinnest fire will take more air and this increases the fuel feed to give a thicker fire. If there are several boilers this action will be progressive, the thinnest fire will catch up with the next thin one, these two will catch up with the next and so on until they are all alike. If peaks are known of ahead of time, additional coal to carry the load may be fed in without changing any adjustments by opening the bypass around the stoker cam.

In the case of fuel oil, pulverized coal or gas, the underlying principles of control are substantially the same but the hook-up is changed due to the characteristic difference between fuel beds and furnaces burning imponderable fuels. In this system, with solid fuel beds the fuel feed follows the change in the rate of combustion but with imponderable fuels this is reversed and the first step in changing load is to change the fuel. Other functions of the operation, namely, the air for combustion and the draft, follow the fuel feed.

With pulverized coal taken as typical of this type of fuel, equipment for natural draft operation would be as follows: A steam pressure regulator attached to the fuel feed (valves for oil and gas or an attachment to the pulverizer feeder for pulverized coal) and a furnace pressure regulator would be applied to each boiler to operate the damper. This regulator, however, would be of the variable draft type and so arranged that the draft variations may be made automatically, preferably by connection to the steam pressure regulator. The cycle of operation, then, would be as follows:

A drop in steam pressure, indicating an increased demand, would cause the steam pressure regulator to operate. This, in turn, would supply more fuel to the furnace through valves, or change the pulverizer feeder. At the same time, the motion of this steam pressure regulator would increase the tension of the draft spring on the balanced draft regulator and a new draft would be established in the furnace of sufficient intensity to draw into the furnace the additional amount of air needed for the increased supply of fuel.

In the larger plants, using forced draft and preheated air, the fuel would be controlled from the steam pressure and at the same time more air would be admitted to the furnace by changing air gates or changing fan speeds, substantially the same as with stokers. On each boiler a balanced draft furnace pressure regulator would keep the furnace pressure constant. This is done because the air admission to the furnace is more or less of a position set and if the pressure within the furnace is not kept constant there will be varying amounts of air to the furnace for a given position of the air gates; in other words, the air-fuel ratio would change.

When the furnace pressure is kept constant, a given gate position meters a fixed amount of air. The company considers that regulation by means of air gates, taking air from a constant plenum pressure duct with constant furnace pressure, is the most accurate way of doing the metering, although a change in fan speed will do much the same thing, but with more or less lag and not quite so accurately.

STANDARDIZATION has done much for modern industry and it is interesting to speculate as to when the origin of this movement even though the date is buried in antiquity and the movement was probably gradual development of primitive needs rather than the result of spontaneous action.

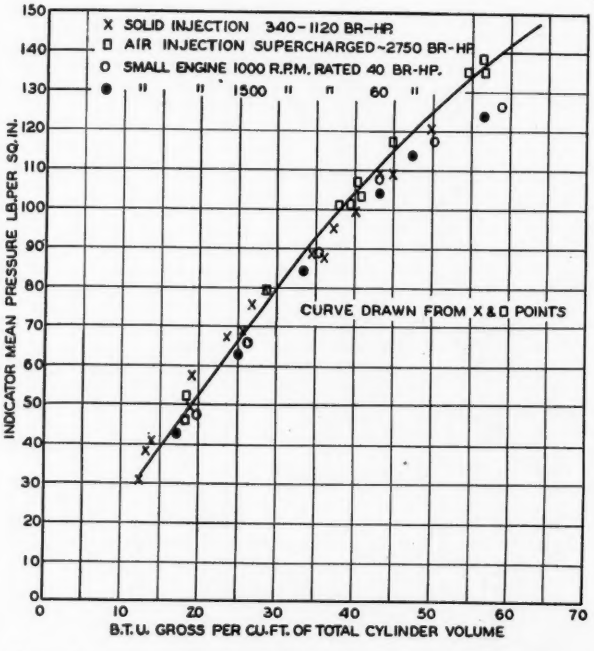
In China the origin of standards dates back to at least 2700 B.C. At that time Huang-Ti, founder of the Chinese Empire, established the so-called five measures. This standard according to Industrial Standards was quite scientific and met the current need for public use. The basis of this system was the distance between two knots of a certain cylinder of bamboo which when used as a whistle produced a definite note.

This bamboo cylinder was then split up into pieces and served as the linear measure, known as "musical scale." It was then divided, sometimes in nine and sometimes in ten parts, or inches. Each inch was further divided into nine or ten divisions, each division approximating the breadth of a grain of rice.

The volume of such a block of hollow bamboo capable of containing 1200 grains was taken as the unit of capacity, 100 units of which made one liter. The weight of such a number of grains was taken as the unit of mass; 16 times this weight being taken as the pound. As the origin of the standards comes from a musical conception, so comes the old proverb, "Same Origin: Music, Length, Capacity and Weights." During the 40 centuries of Chinese history, about 30 changes were made officially in the matter of standard weights and measures. The variations in these changes ranged from 20.50 cm. to 34.30 cm. in length.

Comparison *of* Diesel Engine Performance

DATA ON THE POWER, speed and fuel consumption of a given engine is significant, but gives no clue to the thermal efficiency as compared with the possible or practical performance of much smaller or much larger engines. To establish such a comparison is, however, comparatively simple by means of the rates of fuel consumption and the output. Brake horsepower output is affected by mechanical resistances, so that these values include the effect of both mechanical efficiency and combustion efficiency. A better comparison, as far as the conversion of heat units in the fuel into energy is concerned, is to use the indicated



Comparison of a small 4⅝ by 5⅞ in., 4 cyl. solid injection engine with larger units. The engine is rated at 40 b.hp. at 1000 r.p.m. and 60 b.hp. at 1500 r.p.m. This corresponds to a b.m.e.p. of 80 lb. per sq. in. From motoring tests the friction was found to be equivalent to 24 lb. m.e.p. at 1000 r.p.m. and 28 lb. at 1500 r.p.m.

mean effective pressure. Evaluating the mixture strength in terms of the total cylinder volume makes it possible to compare small engines with large engines.

The curve shown is reproduced from Engineering from a paper read before the Diesel Engine Users Association of England and shows the relation between the mixture strength in B.t.u. per cu. ft. of gross cylinder volume and the indicated mean effective pressure in pounds per square inch for several stationary engines of different capacity. It is apparent that these engines show a close relation to one another in spite of variations in cylinder size, cycle, piston speed and supercharging. Points for a small engine, which has a piston displacement of but 0.05712 cu. ft., show it to be nearly as efficient thermally at all loads and speeds as the others, some of which have a piston displacement of 240 times as great.

Case Studies in Power Economics

Conducted By
ZUCE KOGAN,
Kogan Industrial Service,
Chicago, Illinois

Power Bill Reduced 15 per cent by Replacing Transformers with Others of Lower Capacities

IN THE previous article we discussed a case of a plant where, by taking advantage of changed conditions in the plant, it was possible to get rid of troublesome equipment and at the same time realize a saving. In this article, we wish to describe a case where a plant, taking advantage of changed conditions also brought about a saving in purchased power. It is true that the saving discussed here is comparatively small. This saving, however, was obtained without any cost on the part of the owner of the plant and for that reason it is a worthwhile saving nevertheless.

This plant also consisted of two groups of buildings situated on the banks of a rivulet. About 10 yr. ago when this plant was built up to its present size, both groups of buildings on either bank of the stream were operating at full capacity. The power purchased from the local utility was metered at the primary end and thus the owner of the plant was paying for the copper and core losses of the transformer. The utility, to compensate for this loss, gave this plant owner a reduction of 3 per cent on the total consumption for a given month and 1½ per cent reduction on the total demand established during the month.

Each group of buildings was served by a separate bank of transfomers, each having a total capacity of 600 kv-a., each bank consisting of three 200-kv-a. transformers. During 1931 the production of this plant dropped materially and it was found advisable to concentrate all production in one group of buildings, which we will call Plant No. 1. In Plant No. 2 they have the executive offices and the boiler room, steam for process and for heating being sent underneath the rivulet to the Plant No. 1. It was found that Plant No. 1, in which the entire production was concentrated, had a power demand of 400 to 500 kw., while power required for Plant No. 2 was used for lighting, and for small office equipment in the executive office and power in the boiler room and the entire demand was about 50 kw. The monthly energy consumption was about 7000 kw-hr. In other words, there was in Plant No. 2 a condition where a bank of transformers having a capacity of 600 kv-a. was used to transform a load in the neighborhood of 50 kw. This condition continued till about the beginning of 1935.

To show our client what loss he was incurring by purchasing 50 kw. through a 600-kv-a. transformer, we obtained charts from the manufacturer of this transformer, in which were given both the core and copper losses of the transformer at full load. It was shown there that the core loss was approximately 900 w. per hr. per transformer, or for the three transformers of the bank was 2700 w. per hr. The copper loss was 13,500 w. at full load. Now, since the load was almost one-tenth of full load, the copper loss at a load of 50 kw. would have been one-hundredth (the square of one-tenth) of the loss, or 135 w. per hr. for the three transformers. The load factor of this plant was normally around 20 per cent. Hence, it meant that he was drawing an equivalent of 50 kw. for 20 per cent of the number of hours in a month or for 146 hr. (730 hours x 20 per cent). Hence, the copper loss during the month was $135 \times 146 = 19{,}710$ w. The core loss, which is continuous for 24 hr. a day, or 730 hr. a month, was $2700 \times 730 = 1{,}971{,}000$ w. Hence, the loss he had during the month, due to the core loss and copper loss of the large transformer, was approximately 1,991 kw-hr. per month. We compared this loss with what he would have incurred by changing these transformers to a 75-kv-a. bank consisting of three 25-kv-a. transformers. Upon checking the losses it was found that the hourly core loss for the three transformers would have been 510 w., or for the 730 hr. it would have been approximately 369 kw-hr. per month. The copper loss at full load of the three transformers would have been 1950 w. per hr. Since, as we pointed out previously, his load factor was 20 per cent, it meant that he was consuming power at the rate of 50 kw. for an equivalent of 146 hr. This meant that his loss for the entire month due to the copper loss in the transformers would have been approximately 285 kw-hr. Hence, total loss due to a 75-kv-a. transformer bank would have been only 654 kw-hr. per month (369 + 285). In other words, by changing his transformer bank from 600 kv-a. to 75 kv-a. he would have had on the average a monthly saving representing the difference of 1991 and 654, or a total of 1337 kw-hr. per month. His lowest rate on energy was 0.83 cent, hence, these 1337 kw-hr. cost him $11.10 a month. Besides, he had a demand charge on his old transformer losses which represented a total of 2.83 kw. (2700 w. core loss, plus 135 w. copper loss). With the 75-kw. transformer bank he would have a demand on the loss equivalent to 2.46 kw. (1950 w. copper loss and 510 w. core loss). Hence, he had a saving of approximately 0.35 kw. per month, which, at $1.60 per kw., amounted to an additional 56 cents saving a month. The total gross saving was $11.66 a month. In view of the fact that the utility gave him a reduction of 3 per cent on his energy and 1½ per cent on his demand, the net saving was reduced to the following: On the energy he obtained a reduction of 3 per cent of 7000 or 210 kw-hr. which amounted to $1.74 and on the 50 kw. demand be obtained a reduction of 1½ per cent equivalent to 0.75 kw. which at $1.60 per kw., amounted to $1.20, or the total reduction was $2.94. Hence, his net saving, due to the change in the transformer, would have been $11.66 less $2.94 or $8.72 per month.

Safety Hints for the Ice Plant

Precautions Discussed With Workmen That Have Helped Reduce Accidents 95 Per Cent in 4 Yr. By J. W. Dickson

SAFETY MEETINGS of the plant employees are held for the purpose of discussing safety precaution in all of its phases pertaining to our work. To prevent accidents we must be thoughtful and cautious.

Some of the most important things about our plants which should be handled and operated with continuous care are treated in the following paragraphs.

Never ascend a ladder if you have any doubt about its having the strength to carry your weight. See that all the steps have the proper strength and are securely fastened. Never ascend a ladder if there is any question in your mind that there is a possibility of its slipping out from under you. In a case of this kind, it will pay always to take the time to prop the ladder at its base or secure it in some other way to prevent slipping.

While working around or on frame buildings that are being repaired or constructed, always keep a constant lookout for projecting nail points in loose boards that are thrown promiscuously around on the ground or the floors. Whenever you see a nail point that you think is liable to injure some one, stop and bend the nail, move the board or call it to the attention of the one in charge of this particular work.

Reports Defects

It is the duty of the ice puller, as well as the engineer in charge, to watch his ice pulling equipment and if he detects any part of this equipment showing signs of wear or defects due to any other cause that are liable to cause him or any other puller injury, he must report such condition to the one in charge of this work and it should be remedied as soon as it is possible to do so. There have been more injuries in our ice plants here due to breaking of some parts of the ice pulling equipment than in all the other departments combined.

While walking over ice tank tops, watch your step and keep continuously in your mind that the tops may tilt as you step on them. When we are watching and expecting to stumble or fall, we are better prepared to protect ourselves from injury if we do fall.

Oilers Have Safety Duties

In the engine room, it is the duty of the oiler to be on the lookout continuously for any irregularity in the operation of any of the machines in his charge. He should see that the governor safety devices are kept in operative positions. These safety appliances are used for the purpose of stopping the machines in case the governor belt breaks or valve gear becomes deranged, and in this way prevent serious damage to machines which would result from too high a rate of speed if these safety devices did not function properly.

Oiling valve gears is a dangerous undertaking and should be done with the greatest precaution. There have been many hands and fingers lost on account of carelessness in oiling valve gears of Corliss engines. The oiler in charge of the engines used in connection with ammonia compressors should be familiar enough with the constant regularity of the operating machines that he would be able to detect the slightest variation in their sound or speed, due to low steam pressure or extremely high ammonia pressure, and if he does not know, he should be taught what abnormally high ammonia pressure can mean in an ice plant. High pressure ammonia gages and high pressure ammonia alarms should be kept in perfect operative condition and should be constantly under the observation of the ammonia machine operator. The greatest precaution should be taken in starting up steam driven machines. This is on account of the liability of water hammer in the steam lines. As a rule, water hammer is very disastrous and I consider it one of the most dangerous hazards encountered in steam plant operation.

In the boiler room, the fireman in charge should be extremely careful and a close observer. He should have intelligence enough to know whether or not all the accessories used in connection with the boilers in service are functioning properly. It is his duty to see that the steam gages are registering the correct pressure and that the water gage glasses are kept clean and the water columns blown down frequently. He should be certain at all times that the pop valves are working properly and are relieving the boilers at the pressure determined by the engineer in charge. A fireman should never fire up a boiler that has been cut out of service without having the engineer, or the foreman in charge, verify the true water level in the gage glass. Many boilers have been ruined and many lives lost by a mistaken water level in a boiler.

Fires Are Real Hazard

Regardless of the department in which you are employed you should be continuously on the lookout for accumulated piles of trash, shavings or greasy waste. Any accumulation of this kind represents a fire hazard and should be removed at once.

Be cautious in handling gasoline or kerosene. Do not strike matches or smoke while cleaning or doing any other kind of work where gasoline is required. Be careful as to where you throw burning matches—it is much safer to extinquish the fire before the match

leaves your hand. Gasoline soldering torches are dangerous to operate and the greatest precaution should be employed while using them. Keep your clothes lockers clean. Do not let old greasy cloth, rags or paper accumulate in or on top of them.

Never use an electric light when it is to be handled unless the globe is protected by a substantial guard. The purpose of these guards is to keep the globe from being broken by striking against any hard object. The glass in these globes is not more than 1/32 in. in thickness and can be broken very easily. When broken due to a shock, the glass will fly into thousands of small pieces at a high velocity and are very dangerous to the eyes and face. It is true the guard does not eliminate the breaking of the globe entirely, but it does reduce the hazard to a great extent.

Replace Gage Glasses With Caution

Breaking of boiler water gage glasses is another hazard and the greatest precaution should be used when replacing glasses in the columns. If you are not careful in this work you are liable to get scalded and cut by the flying glass at the same time. After replacing the glass always turn the steam on before opening the water valve. The steam valve can be slightly opened to fill the glass with boiler pressure and if the glass breaks at this time there will not be enough steam passing through the valve to do any damage. Open the water valve to the glass after you are sure there is no danger of the glass breaking. Never open the steam valves or water valves to gage glasses without protecting your face with something. A shovel or a wide board can be used for this purpose.

Always wear heavy glass goggles when using emery wheels.

Be careful in walking up or down steps, especially if they are slippery. Always keep one hand on the guard rail to steady yourself if you slip or fall. Be cautious in walking around on oil soaked ground or greasy floors. Just a little forethought in such cases will sometimes save you from a hard fall and possibly injury. Be careful not to walk into open elevator shafts or open trap doors.

It is very essential that you should use extreme caution in handling heavy machinery, especially when rope blocks or chain hoists are employed. You should know approximately the weight of the material you are to handle, the capacity of the hoist, the strength of the tie chains or ropes, and the carrying strength and condition of the supporting beam that is to sustain the entire weight. As a rule, when a machine or a part of a machine falls, it results in broken parts and injury to one or more of the employees.

In the past few months there have been several air receiver explosions and some of these explosions have been very disastrous. Keep the receivers free from oil and see that the relief valves are in proper condition to relieve the pressure in the receivers at 2 or 3 lb. above the normal operating pressure.

I believe it would be easy for all of us to learn to be careful. It is natual for us not to want to get hurt, and if we practice thinking as we work how to prevent accidents and the results of accidents, we would in a short time educate ourselves to be precautious in every undertaking.

Reducing Valve Capacities and Characteristics

Complete Information on Service Requirements Needed in Specifying Reducing Valve.

By JAMES O. G. GIBBONS

DIFFICULTIES are sometimes caused by the installation of reducing valves and other pressure control equipment which are not suited for the requirements of the service. To many people a reducing valve appears to be just a reducing valve in the same sense that a gate valve is a gate valve and a globe valve a globe valve. As a rule, any gate or globe valve of good make which is the same size as the pipe in which it is installed will be quite satisfactory, but it is only by good luck that this will be the case with a reducing valve.

Much of the difficulty is no doubt due to the fact that manufacturers generally list their reducing valves in accordance with pipe sizes and publish little or no information as to capacities and operating characteristics under different conditions.

Size of Valve

The first point to be considered is the correct size of the valve. This need not necessarily bear a direct relation to the size of the pipe feeding it. It is well to choose a valve the maximum capacity of which is not very greatly in excess of the maximum steam demand, as it is much better to have the valve working nearly wide open most of the time than to have it nearly closed and wire drawing. Not only is there a saving in cost of installation, but a moderately sized valve will operate better.

In the preparation of this article, data was collected from three leading manufacturers. One company supplied a table, which did not, however, state the outlet pressures so it is left for the purchaser to guess as to whether or not the quantities given represent maximum capacities.

The nature of the curves supplied by, let us say company B, led me to believe they were made up from a formula, and by taking Napier's formula, (Flow in lb. per sec. = abs. pressure, lb. per sq. in. $\times$ area in sq. in. $\div$ 70) assuming that the orifice area was 0.75 of the square of the pipe diameter, and assuming that the maximum output was reached when the outlet pressure was 50 per cent of the inlet pressure (the curves indicated this) then multiplying the result by 3600 to get pounds per hour instead of per second, I came to the conclusion that the curves were made up by using Napier's formula slightly modified.

Now when we come to the data supplied by company C, we find that although there is not much difference between the capacities for the 1 in. size valves of companies A and B, there is such a wide difference in the larger sizes that it is quite clear that neither Napier's nor any other well known formula

can be applied, the data evidently being the results of tests. From the foregoing information I drew the conclusion that the only safe way to ascertain the maximum capacity of a valve is to ask the manufacturer for a guarantee of results.

Flow a Function of Pressure Difference

It should be kept in mind that the maximum weight of steam which will pass through a reducing or pressure control valve is a partial function of the difference in pressure between the high and low pressure sides but there is a certain point beyond which an increase in pressure differential ceases to be effective. For practical purposes, the maximum effective differential may be assumed to be approximately 60 per cent of the initial steam pressure. That is, the same valve will pass no more steam when it is set to reduce from 100 lb. to 20 lb. than it will when set to reduce from 100 lb. to 40 lb., but for smaller pressure reductions, a decrease in pressure difference will reduce the quantity of steam which will pass through the valve, and when a valve is required to reduce a variable high pressure to a constant low pressure, it is important to be sure that it is of sufficient capacity to pass the required amount of steam when the pressure differential is at its lowest value.

It will be seen that no notice has been taken of the sizes of the steam lines leading from and to the valve. This is an independent problem and should not be permitted to play a too prominent part in the choice of the valve itself, although it is too often made the governing factor. There appears to be a rather prevalent misunderstanding as to the limit of steam flow when the pressure is reduced through an orifice. Some people are not aware that there is any limit other than that due to pressure drop, and some think that the same limit applies to the flow of steam in pipes.

Perhaps a reference to the flow of direct current electricity will throw some light on the matter. We all know that Ohms law states that $I = E/R$, that is, the rate of flow is equal to the EMF (Pressure) divided by the resistance, and in the case of a lighting circuit E is the line voltage. The flow of steam in pipes follows a very similar law. Now, if instead of a lighting circuit we take a motor circuit, the law is not changed but we must take the impressed EMF minus the counter EMF generated by the motor to equal E. A reducing valve is really a power converter and the expanding steam sets up a back pressure similar to the counter EMF of a motor.

Resistance to Flow

Let us assume high pressure steam at 100 lb. and the valve is set to reduce the pressure to about 40 lb., a certain weight of steam will flow per minute with maximum valve opening and this flow is determined by three variables. The resistance offered by the valve opening, the difference in pressure between the high and low pressure sides and the reaction of the expanding steam, and it so happens that if the valve is adjusted to reduce to any pressure lower than 40 lb., such as 30 lb., the other variables will so adjust themselves that the steam flow will not exceed the maximum possible at 40 lb. In the case of a steam main we have, as a rule, no expanding steam so the rate of flow is subject without limit to steam pressure and the pipe resistance.

This may not be a very scientific explanation and it is not intended to be, but it may serve to reduce the element of mystery which often hovers about this subject.

In selecting a reducing or pressure control valve, it is most important to remember that a double seated valve will not shut off tight, or at any rate it is not at all safe to assume that it will, and in the case of large valves the leakage may be considerable, therefore the smaller the valve, not only the cheaper but the better, provided of course that it will handle the maximum amount of steam required.

Single seated valves, except for small differences of pressure, must be pilot operated and should have plenty of operating power if it is important that they close off tight, a small leak may build up a dangerous pressure on the low pressure side when the demand for steam is cut off.

Serious difficulties are sometimes encountered through neglect of this and the desire to save money by the use of a double seated balanced valve where a pilot operated positive cut-off valve should be used.

These points have been discussed at some length because it has been the writer's experience that unless the purchaser of this class of equipment is fully aware of the difficulties which may be encountered and is careful to obtain accurate information from a qualified representative of the manufacturer, there is always a chance of trouble.

Reducing valves can be bought from almost anybody, but it is not everybody who has the necessary information and technical knowledge to recommend a valve best suited to the service. On the other hand, it is equally important that the purchaser should furnish complete information as to the exact requirements of his service, otherwise he will only have himself to blame if he does not get the right kind of valve.

Free Ions Invigorate Air

While it is possible, by control means, to produce an atmosphere in a room of the right temperature, of a satisfactory humidity, properly cleaned and of good chemical condition, reasonably free from odors, it still seems to lack that mysterious something that one finds in the mountains or at the seashore. That invigorating quality that makes one enjoy just breathing such air.

Studies have been made to determine the cause of this difference. The most generally accepted theories now attribute it to differences in the kind of free ions that exist in the air. Some studies have been reported which show quite striking differences on persons subjected to these influences. When there is a preponderance of positive ions it appears to slow up the mental activities to such an extent that well educated persons, acting as subjects in the tests, were unable to add columns of figures that would ordinarily require little effort.

Conversely, when the negative charges predominate there was increased mental activity and a feeling of bouyancy.

These studies though not complete may eventually make possible the regular production of an ideal atmosphere. (Westinghouse.)

As One Engineer to Another—

Combustion Principles and Flue Gas Analyses Along with Some Examples in Arithmetic Are Interwoven to Clarify Heat Losses. By G. F. WETZEL

YOU KNOW, G. F.," the Chief said as we were visiting once more in his office,—"You know, I have been thinking—"

"I hope you stood the strain all right," I interrupted, yielding to the impulse to tease him a little.

"Okay, G. F.," the Chief said. "Have your fun, it will not stop me in my efforts to learn more. So we will just skip a recital of my musings and get down to the subject of today's lecture. What is it, Professor?"

"We have not gone into combustion and the significance of CO_2 yet, so we might spend a little time on that. Since you have no specific problems of your own this time, I will give you something to think about, and suggest you make notes, and ask any questions that occur to you, as we go along."

"In all our fuels there are just three elements that burn—carbon, hydrogen, and sulphur. Carbon is the most important because it is always present in the biggest proportion. The sulphur is the least important from the heat standpoint, because its heat value is low and there is not much of it, although there is always some present. It can be ignored in heat calculations, because even the small amount shown in the ultimate analysis is liable to be partly combined in the ash, so that the amount available for combustion is indefinite. Sulphur is undesirable because it tends to form an acid which is very corrosive on all iron and steel, and it increases the clinkering properties of coal. So we will drop sulphur from now on in our discussion.

"Hydrogen is a valuable constituent, having a very high heat value. All that cumbustion consists of is the chemical combination of the oxygen in the air with the carbon and hydrogen in the fuel. The oxygen in the coal is assumed, for engineering purposes, to be combined with its proper amount of hydrogen, as H_2O."

"Did you say oxygen in the coal?" the Chief interrupted.

"Right, Chief," I answered. "Coal will contain from 3 to 20 per cent, or sometimes even more, of oxygen by weight, according to the ultimate analysis of a large number of bituminous coals. But when you stop to consider that 1 lb. of hydrogen requires 8 lb. of oxygen, there will always be hydrogen left after the oxygen in the coal is all balanced up with its proportion of hydrogen. Oil also contains some oxygen, but not so much, usually around one per cent.

"You know of course that air consists of 23 per cent oxygen and 77 per cent nitrogen, by weight, and 21 per cent oxygen and 79 per cent nitrogen by volume. Chemical equations are all based on weight, so that in figuring the air requirements of fuels, we would find pounds of air per pound of fuel. Flue gas analysis is based on volumetric measurements. Oxygen is the active element and nitrogen just tags along, each pound of oxygen used dragging along 3.35 lb. of inert nitrogen. You can see that this is a decided heat loss because it goes into the furnace at say 90 deg. and is discharged up the stack at around 500 deg., although it performs the function of a heat carrier, absorbing its share of the heat liberated by the combustion, and carrying it to the heat absorbing surfaces of the boiler. It also, by diluting the oxygen, keeps the temperature down to a practicable point. Here is a chance to do a heat-quantity problem. Assume that 10 lb. of air is required to burn 1 lb. of fuel, and that the specific heat of nitrogen is the same as for air, 0.24. How many B.t.u. will be lost per pound of coal because of the nitrogen?"

"That's easy," the Chief answered. "Just use the heat equation:

$$H = CW\,(t_1 - t_2)$$
$$H = 0.24 \times 10 \times 0.77 \times (500 - 90)$$
$$= 758 \text{ B.t.u.}$$

(C is specific heat: W is weight: $(t_1 - t_2)$ is temp. difference: 0.77 is 77 per cent nitrogen in air.)

"Fine, Chief," I continued, "I suppose you know the chemical symbols of the elements you deal with every day—C, carbon; O, oxygen; N, nitrogen; H, hydrogen; S, sulphur, and that each one forms definite compounds when burned, except nitrogen, which does not burn. Put this table down in your notes:

Element	Forms	Lb.O	Lb.Prod.	Lb.Air	Lb.Flue Gas	Atomic Weight
C	CO	1⅓	2⅓	5.79	6.79	12
C	CO_2	2⅔	2⅔	11.58	12.58	12
H	H_2O	8	9	34.8	35.8	1
S	SO_2	1	2	4.35	5.35	32
O	...	...	...	....	....	16
N	...	...	...	....	....	14

"In this table we have the results of combustion, with the weight of oxygen, weight of products of combustion, weight of flue gases (including nitrogen) all based on one pound of the element in the left hand column, and the atomic weights. From it we see that our atom of carbon combines with one atom of oxygen to form CO (carbon monoxide). One volume of oxygen combines with carbon to form two volumes of CO, which weighs therefore, ⅞ as much as the same volume of oxygen. To form CO_2, one atom of carbon combines with two atoms of oxygen, weighing 1⅜ times as much as oxygen per volume, or 1.52 times the weight of air per volume. One volume of oxygen results in one volume of CO_2."

Here the Chief had a question, "In the second col-

umn of the table you had H_2O which is water. Where does the water come from?"

"Remember Chief, combustion as we said before, is just as much a chemical reaction as putting the proper chemicals in a test tube and bringing about a reaction. All fuels have some hydrogen in them, and regardless of its combination in the fuel, if not already combined with oxygen to form water, it will burn to form water just the same as if you burned pure hydrogen in an oxyhydrogen flame. In fact, the whole combustion process gives the same result as to heat liberation and products as if each element were burned separately.

"I don't know why it is, Chief, but nearly every operating engineer I know thinks there is something mysterious about combustion and CO_2. Just to show you that it is not hard to understand, I am going to give you another problem to do. Assume a coal with this analysis:

Carbon	70%
Hydrogen	5.5%
Oxygen	15%
Ash and sulphur	9.5%

"How much air would be required for the theoretically perfect combustion per pound of fuel? Disregard the sulphur. Here is a hint: From your table you have the amount of air required for a pound of each element. And remember I told you the oxygen in the fuel is considered as being combined with its corresponding amount of hydrogen (8 lb. oxygen to 1 lb. hydrogen), the remainder of the hydrogen requiring oxygen from the air."

"Okay, G. F. I think I get the idea," he replied as he took his pencil and started.

"If it takes 11.58 lb. air for a pound of carbon and we have 70 per cent or 0.70 lb. that will take 0.70 $\times$ 11.58 or 8.1 lb. If it takes 8 lb. oxygen for 1 lb. hydrogen, and we have 15 per cent or 0.15 lb. of oxygen, it will take $\frac{1}{8}$ its weight of hydrogen or 0.15 $\div$ 8 lb. hydrogen or 0.0187, or 1.87 per cent. We had 5.5 per cent hydrogen to begin with which leaves 3.63 per cent, i.e. (5.5 — 1.87). 0.0363 $\times$ 34.8 lb. air per lb. of hydrogen is 1.26 lb.

Air for burning carbon	8.1 lb.
Air for burning hydrogen	1.26 lb.
	9.36 lb. air per lb. coal.

"Good work, Chief," I told him. "You see that was neither mysterious nor difficult. Now from the figures you have, give me the maximum per cent of CO_2 we could get. Remember, one volume of oxygen becomes one volume of CO_2, and air has 21 per cent by volume of oxygen."

"Wouldn't that just be 21 per cent times the ratio of air required to burn the carbon compared with the total weight of air required to burn the coal, or 8.1 $\div$ 9.36 $\times$ 21 per cent?" he asked.

"That is almost all there is to it," I answered. "Don't forget that your hydrogen becomes water, in vapor form, which will condense out of the flue gases before you could analyze them. Therefore, out of the air allowed for burning the hydrogen, you must deduct the volume of the oxygen which is 21 per cent and which will end up as liquid water. In this case it would be 21 per cent of 1.26 or 0.26 lb. Therefore, the maximum CO_2 would be 8.1 $\div$ 9.1 $\times$ 21 or 18.7 per cent by volume.

"Now suppose we take fuel oil, which would have, for a medium grade, approximately this analysis:

C	85.0%	N	0.2%
H	12.0%	O	1.0%
S	0.0%	H_2O	1.0%

You work out the air required and maximum CO_2, by yourself, and see how easy it is."

In a few minutes he showed me his note book with the solution.

Carbon: 0.85 $\times$ 11.58 = 9.84 lb. air. (0.85 = 85 per cent, 11.58 = lb. air per lb. carbon.)

Hydrogen: 0.12 $\times$ 34.8 = 4.18 lb. air. (0.12 = 12 per cent, 34.8 = lb. air per lb. hydrogen.)

Total air = 14.02 lb. for perfect combustion CO_2 occupies same volume as oxygen before combustion, which was 21 per cent by volume of the air supplied:

$$CO_2 = 21\ \% \times 9.84 \times 13.35 \text{ (vol. cu. ft.)}$$

$$H_2O = 21\% \times 4.18 \times 13.35 \text{ (vol. cu. ft.)}$$

$$\text{Total volume} = [9.84 + 4.18 - (0.21 \times 4.18)] \times 13.35$$

$$= 13.14 \times 13.35 \text{ cu. ft.}$$

$$\text{Per cent } CO_2 = \frac{9.84 \times 13.35}{13.14 \times 13.35} \times 21\%$$

$$= \frac{9.84}{13.14} \times 21\% = 15.8\%$$

(13.35 is vol. of 1 lb. dry air at 70 deg. F.)

"You are really getting good, Chief," I complimented him. "That is a good, clear solution. From this work you can see that the important thing to know is the weight of air required for theoretically perfect combustion.

"Now, you know as well as I do that we can not burn coal or oil completely by supplying just the exact amount of air required to balance the combustible in the fuel. The reason is that to get perfect combustion every molecule of fuel must come in contact with oxygen, which is impossible in our boiler furnaces without supplying an excess of air, which will run from 10 to 50 per cent. When you consider that every bit of excess air is also excess baggage, carrying the heat away the same as the nitrogen in the necessary air, you can see that it is very important to keep the excess air down to the smallest possible amount which will permit complete combustion in any given furnace with the fuel used."

"You have seen flue gas analyses made, and have often heard about the per cent of CO_2. Its importance lies in the fact that it is the best indication we have of the combustion conditions and the amount of air supplied. We have seen that it is necessary to supply a certain amount of excess air, and the aim is to supply as little excess as possible and still get complete combustion. The amount of excess air required depends on the size and type of furnace, the load on the boiler, and the fuel used. The excess air brings about a loss in two ways—it lowers the gas temperature which cuts down the rate of heat transmission from the gases into the water in the boiler, because the rate is dependent on temperature difference—and more heat is discharged up the stack due to a greater weight of gas going through the boiler. To illustrate what CO_2

percentage shows, suppose we found it to be 6 per cent, burning the same coal you figured on before. Refer to what you did to find the maximum CO_2"

So the Chief picked up his pencil again, and after reading over his problems done previously, and stopping to think a few minutes he put it down like this:

8.1 lb. air was required to burn the carbon
1.26 lb. air was required to burn the hydrogen
0.25 lb. oxygen was burned to water vapor
Let W = weight of air supplied

$$CO_2 = 6\%$$

$$\frac{8.1}{W - 0.26} \times 21\% = 6\%$$

$$8.1 \times 21 = 6\,(W - 0.26) = 6W - 1.56$$

$$W = \frac{8.1 \times 21 - 1.56}{6} = 28.09 \text{ lbs. air.}$$

Air required = 9.36 lb.
Excess air = 28.09 — 9.36 = 18.73
Per cent excess = 18.73/9.36 = 200% excess

"Nice work, Chief," I told him after looking it over. "After this you can't ever tell me you don't know about CO_2 percentages. Your analysis is Okay and you can see from the answer that in this case 6 per cent CO_2 means putting three times the theoretical amount of air through the boiler, or at least twice the amount necessary for good combustion.

"We haven't gone into what happens when instead of an excess of air, there is not enough completely to burn the fuel in a furnace. In this case, the combustible elements, carbon and hydrogen, would not be fully oxidized, and there would be CO, some CO_2, H, and probably some O in the flue gases, meaning a loss in the form of unburned fuel. CO, carbon monoxide, has a heat of combustion of 4440 B.t.u. per pound, while if burned completely to CO_2 it would have a value of 14,600 B.t.u., and the latter value is true whether the reaction takes place in one or two stages. The heat of combustion of hydrogen is 62,000 B.t.u. per pound, if the resulting water vapor is condensed and gives up its latent heat of vaporization. If it is not condensed it will carry away the latent heat plus the superheat, and reduce the value of 62,000 B.t.u. by a corresponding amount, depending on the final conditions of the combustion products.

"The CO_2 analysis gives some very valuable information, especially if the continuous recorder is used, and watched, and the information it gives is used."

"Well, Chief, once more you have something to think about, and I must be going. So long!"

Combustion Control at the Taunton Municipal Plant

OUR ATTENTION HAS been directed to an error in the list of equipment which appeared with the article on the Taunton Municipal Lighting Plant in the July issue. In this list, the combustion control equipment should have been credited to the Hagan Corporation instead of the Hays Corporation. The Hays Corporation furnished draft gages and certain other instruments but the combustion control equipment was furnished by the Hagan Corporation.

Waste Prevention

ARE YOU conscious of waste on the work you are doing? This question was propounded by T. H. Owens of the Westinghouse Electric & Mfg. Co. at the Spring Meeting of the A. S. M. E. Mr. Owens proceeded to answer his own question by telling what his company had done along that line.

Every non-standardized product sold entails expense for development, extra set-up in the manufacturing departments, special handling, and sometimes patterns and tools. The standardized product has been tried and proved; therefore, it should be better for the user than a specially manufactured product. Also, it can be delivered more quickly and its cost is lower. Sell standards wherever possible.

In the design departments, design new and special products as to make use of the maximum number of standardized parts and available tools, patterns and other manufacturing facilities.

In the clerical departments, use one form or piece of paper wherever possible, instead of transcribing from one to another. This simplifies the routine, makes it more direct and eliminates expense resulting from errors of transcription.

Standardize on a minimum of sizes and varieties of materials and products, so as to get the advantage of quantity purchases and manufacture, lower investment in stocks, and fewer varieties of small tools, machine tool set-up, etc.

Note repeat orders for non-standardized parts and materials and have them authorized for stock when the demand justifies quantity production. This affords large savings in machine set-up cost and handling of special orders.

When short ends, centers and trim of commercial-size materials are left over, always see that they are used before giving out full-size bars, rods, sheets and strips. It pays to watch the scrap pile for this sort of thing.

Trace waste materials back to their source and try to prevent their coming into being. Remember that an ounce of waste prevention is worth many pounds of salvage and reclamation.

Take every possible advantage of welding in the manufacture of your products and on your reclamation operations.

When considering your scrap materials, think about modifying or treating them in any way that may permit their being used at your plant or sold to someone else for use.

Prepare your scrap materials for sale in such form as will bring the best possible market price.

It pays to look over the expense materials used in the offices and the shops and make certain that they are the most economical in kinds and sizes for the use to which they are put. This should include all office equipment and supplies, and everything in the shops that is not used on direct production.

Be alert to leaks at water spigots and gas and compressed air valves, lights burning needlessly and powered devices operating idle. These easily avoidable losses are not as conspicuous as those incurred on scrapped materials, but they make up a considerable part of the waste bill.

The Modern Note in Plant Construction

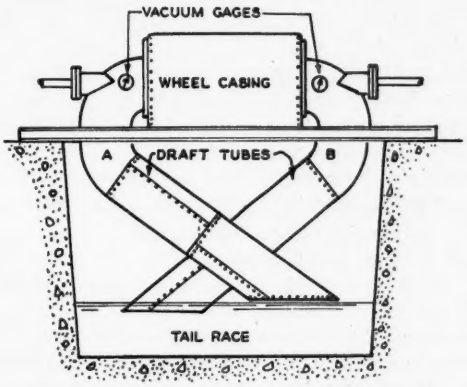
THE MODERN NOTE in the construction of the new Diesel-Electric Locomotive plant of the Electro-Motive Corp. at McCook near Chicago is one of low intensity. For this plant is being assembled entirely by the electric welding process and instead of the ear-splitting clatter of riveters usual with steel construction, here is heard only the swish of the welding arc. This, however, is only one of many unusual features of this plant which is being built by the Austin Co. It is the first large plant designed entirely in the modern manner. Horizontal windows completely encircle the buildings which have been designed on functional lines. Also it is the first plant built for production of locomotives on an assembly line basis. Power will be supplied directly by Diesel electric units designed for locomotive use. The 200 t. crane to be installed will be the largest ever to be electrically welded and the annealing ovens, 22 by 200 ft. are being constructed so as to receive the entire frame of the largest locomotive ever built at one heat. Another interesting feature is that it will be possible to use the power generated by the locomotives on stationary tests in plant operations. The Electro-Motive Corp. is a subsidiary of General Motors Corp. Its locomotives will be powered with Winton Diesel engines manufactured by the Winton Engine Co. in Cleveland, also a G. M. subsidiary.

Readers' Conference

Faulty Draft Tube Causes Governor Problem

TWO MODERN horizontal hydraulic turbines were installed and equipped with a quick acting hydraulic governor which controlled the speed within one per cent. When shortage of water occurred, however, the governor was operated on one wheel only and the power was very erratic.

Several governor experts from the factory had to admit defeat until a genuine trouble-shooter had a pair of vacuum gages placed on draft-tube elbows, shown here. Draft-tube A was clear of the water and no seal could be obtained, therefore no vacuum. When the speed slowed, the governor opened the gates, a seal was established and away went the speed. When the governor partially closed the gates the vacuum was broken and speed slowed. The governor was O. K. but the draft-tube was faulty. A small dam, causing back water cured the trouble.



Two vacuum gages installed on the draft tubes showed why the governor wouldn't work

New York City. C. W. PETERS.

Simple Kink for Unstopping Plugged Drain

LOSS OF CONSIDERABLE ammonia and a troublesome shut-down as well due to a plugged drain line, was averted in a way that might have any number of applications. The drain line on the high pressure ammonia receiver in our ice plant is a half inch line with an angle valve next to the receiver. It was recently discovered that this line had been plugged for some time and that the receiver was approximately one-third full of oil and sludge. (The level of the oil was estimated by the temperature of the receiver wall.)

It was impossible to punch out the drain line because of the angle valve and due to emergency repairs made in previous years it was impossible to remove the ammonia from the receiver without losing the contents of the receiver and half the condenser. A screw type gage tester with a thousand pound gage attached was filled with oil and connected to this plugged line by a quarter-inch line and bushing. By raising the pressure with the gage tester, a pressure of a little more than 400 lb. was obtained. When the pressure was sufficient the obstruction in the line was forced back into the receiver which carried a pressure of 180 lb. After the gage tester was disconnected, the oil and sludge were easily blown out of the receiver.

Freeport, Texas. R. F. PARKER.

Correct Installation of Bearing Seals

IT IS IMPORTANT that dirt be excluded from and the escape of lubricant prevented from any bearing. This makes some form of bearing seal necessary. Felt rings for bearings are quite satisfactory for retaining lubricants of a soft to medium consistency under average conditions of cleanliness, provided a speed of 1000 r.p.m. is not exceeded. The surface on which the felts rub should be polished and smooth. They should be made of a high grade wool felt and completely fill the grooves in which installed. For high speed, harder felts should be used than for low.

Inferior felts are likely to glaze harder and tear quickly. Before fitting, these rings should be soaked in oil. This will make them more pliable and they will not absorb the bearing lubricant. Leather seal rings are satisfactory for moderate speeds and comparatively clean conditions. These rings should be soaked in oil for at least 24 hr. before installation. This will make them soft and pliable, otherwise they will create considerable friction which may destroy the leather due to charring.

Groove seals have been found satisfactory for all speeds and with all lubricants. These seals have a number of grooves cut in the bore or on the outside diameter depending on the design. With oil these grooves break the capillary action and so prevent the escape of oil, if used with grease, the grease will pack hard in the grooves and make a tight closure. The width of each groove should be between 1/8 and 3/16 in. The distance between the grooves should be half the width of the groove, and the depth of each groove between 5/32 and 3/16 in.

Not less than three grooves should be used. Provided the bearing clearance is kept small, these clearances are highly efficient, but if this clearance increases due to wear or other cause, the efficiency of the seal will fall.

Another type of seal very suitable for use under severe conditions of dust are cork seal rings. These rings are made of finely ground natural cork held together by a suitable binder. Before use these rings should be soaked in oil for at least 5 hr. and on assembly a small amount of grease should be applied to the inside of the ring.

Kent, England. W. E. WARNER.

Allowance for Pipe Expansion

On page 362 June Power Plant Engineering, C. W. Peters states that a little knowledge of mathematics is a dangerous thing for an engineer to possess. Perhaps it is, under certain conditions, but no knowledge is a much worse condition in this writer's opinion.

I have run steam heating lines up to 1400 ft. in length, inside and outside of tunnels and never had any trouble with expansion or contraction. Of course I always made provision for such.

Nearly every, if not all, operating or chief engineers will do the same. Office engineers with no practical experience may need seven figures in decimals when laying out long steam runs, but a practical installing engineer never does.

It makes no difference what system is used, elbows, turns, expansion-joints and so forth. Expansion is so well known now that not one installing engineer or pipe-fitter in a thousand will fail to allow the over limit for expansion and contraction in steam lines, no matter what pressure is to be used inside the lines.

A knowledge of mathematics is necessary when installing long steam pipe runs, if the installer has no experience in such work and is ignorant about the steam pressure; but in most cases no great mathematical knowledge is required when installing steam pipe runs no matter what diameter pipe is to be used, and no matter what the pressure is.

The whole matter can be safely estimated in a short time.

Toronto, Ont. James E. Noble.

Best Point for Continuous Blowdown

Continuous boiler blowdown is being used more and more these days, and is being recommended by leading boiler engineers. Its purpose is to remove continually the highest salt concentration from the boiler water.

A question that has commonly come up in this connection is, "What is the best point in the boiler from which to take the water for continuous blowdown?" In an effort to settle the point I sent out a number of letters to various authorities in which I asked these three questions:

1. Is the bottom of the boiler the best point?
2. Or a point near the surface of the water?
3. Or from the surface of the water?

One of the letters, directed to the Bureau of Mines, received the following reply:

"The type of the boiler and other conditions affect the choice of location. For an ordinary cross-drum straight-tube boiler the pipe opening is often placed toward the bottom of the drum, low enough to be well below the lowest water level. On the Stirling type boiler, it has been placed in the lower drum and also in the front steam drum. If a water is known to have slightly higher concentrates near the surface that should be removed in this way, the opening could go nearer the surface. Plants using continuous blowdown are usually careful about feedwater treatment, and a short distance either way in an upper drum is unlikely to make much difference."

A concern prominent in the treatment of boiler feedwater replied:

"We recommend that a continuous blowdown should be installed so as to take water from a point far enough below the surface to avoid getting steam into the blowdown (approximately 6 in. below the surface) and at the point of maximum concentration in the boiler.

"In a B. & W. cross-drum type boiler, for instance, this would be just forward of the baffle which deflects the steam and water from the cross-over tubes.

"In a four-drum boiler of the Stirling type, the best location would be in the center drum.

"In a three-drum boiler of the Ladd type, the front drum would be the proper place."

A large steam specialty concern, well known to all readers, wrote:

"Our experience leads us to believe that it is impossible to predict ahead of time just where will be the best location for the blowdown connections. Generally the blowdown connections have to be changed several times before the best location is found after the continuous blowdown system is installed. Experience seems to have pretty well established the fact that the greatest concentration of soluble and suspended insoluble impurities will be found in the mud drum of a straight tube boiler and in the bottom headers of water walls, especially when recirculators are used.

"When continuous blowdown systems are applied to such boilers, good practice is to use a number of very small connections approximately uniformly spaced across the length of either the mud drum or the water wall bottom headers, or both, and to join these into a common pipe which leads to the blowdown system. In bent tube boilers the general practice is to blowdown the mud drum and the bottom water wall headers in about the same way. Of course, under certain conditions it is also desirable to use surface blowdown connections, especially when a large amount of floating scale is present. When surface blowdowns are used they should be placed in the least active drum where the surface disturbance is so little as to permit the floating scale to collect on the surface and remain there."

Another large concern in the boiler field said this:

"The purpose of a continuous blowdown is to remove from the boiler water all the highest concentration possible, therefore, this blowdown should be connected to that part of the upper drum to which the greater pressure of steam is delivered.

"In a straight tube sectional header boiler this point is, of course, below the water line in the drum and toward the forward side of the drum, or directly under the steam circulating tubes. It should be as far as possible from a point where the boiler water could be diluted with incoming feedwater.

"In a four drum bent tube boiler the blowdown should be taken from the front or second upper drum, preferably the front drum, unless the boiler is designed so that the circulated water all passes through into the rear or steam off take drum."

A large power plant equipment concern, also well known to every reader, wrote:

"Our policy in withdrawing water from boilers with the use of continuous blowoff equipment is to take this water from the point of highest concentration in the

unit. For example in a bent tube boiler we consider that this point is in the front drum.

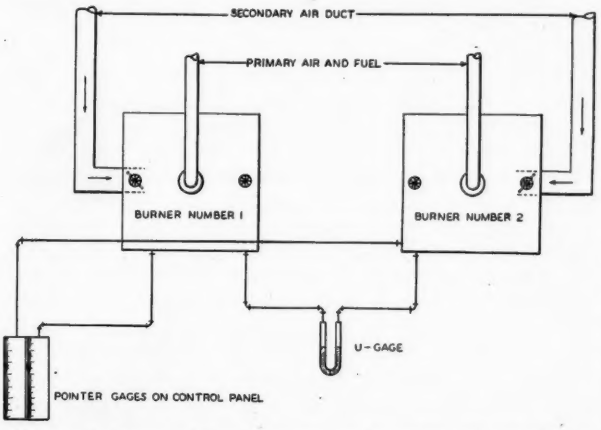
"We take the water about mid-way between the surface and the bottom of the drum, the reason for this being that if something should happen to the continuous blowoff valve there would be no possibility of draining the water from the boiler totally as might be the case if the blowdown connection were made from the mud drum. Of course you appreciate that this is not likely to happen even in the event of such failure because of the small sizes of these continuous blowoff lines. There may be occasions, however, when the lines are made larger than actually necessary, so as to avoid any accidents of this sort, this policy is followed. The location of our continuous blowoff system in this manner is not with any idea of taking water from the surface but rather from the point of highest concentration of dissolved and suspended solids."

And, finally, the engineer of a boiler manufacturing company of world wide repute called me on the telephone and said, in substance, "Take the water from a point 3 to 4 in. below the water line, which is the point of greatest concentration."

Newark, N. J. W. F. SCHAPHORST.

Balanced Burner Conditions Obtained With U Gages

WHEN FIRING pulverized fuel with horizontal turbulent burners it is extremely important that all burners be operated at as nearly as possible equal ratings. Individual burners should be adjusted so that fuel supply, air flow, degree of turbulence and flame shape are approximately the same as on every other burner. In this manner furnace volume is uniformly and efficiently



U gage indicates relative air pressures in pulverized coal feeder windboxes

utilized and firing procedure, under given conditions of boiler load, is standardized.

In one large industrial boiler plant, due to the relative remoteness of the boiler control board from the pulverized fuel burners, equalization of secondary air pressure in the burner windboxes is simplified by the installation of U gages. These gages, containing colored fluid, are mounted in plain view of the manually operated burner controls.

The boiler operator, when operating these controls, has only to note the relative height of liquid in each leg of the U gage to determine the degree of balance between air pressures in each windbox. After balanced conditions at the burners are obtained, changes in boiler rating are handled at the boiler control board by equally varying the rate of fuel flow to each burner and adjustment of forced and induced draft fan speeds to obtain the correct air-fuel ratio.

Waynesboro, Va. S. H. COLEMAN.

Oil In Boiler Feedwater

ON PAGE 474 of the August issue there is an article by W. F. Schaphorst suggesting a method for determining the quantity of oil in boiler feedwater. I believe that every power engineer will agree that he would rather have feedwater free from oil rather than any kind of an indicator to determine the quantity.

The oil, of course, comes with the exhaust from reciprocating units. It should be removed from the exhaust steam before it reaches the heater but sad experience with inefficient oil separators has led many operating men to conclude that oil in exhaust steam is a nuisance to be endured and that the cure must be applied to the feedwater rather than to the exhaust steam itself. The difficulty lies in the fact that all oil separators are not efficient enough for this purpose. A high efficiency steam purifier is required and there are designs which may be depended upon to remove all the oil from exhaust steam. One user actually sent samples of condensate out to a laboratory but the chemists were unable to find any trace of oil.

An efficient purifier is, in my opinion, more desirable for this duty than either cloth or sand filters since it requires no attention after installation while cloths must be washed free of oil and sand must be periodically replaced. Furthermore, filters of this nature will pass oil after becoming saturated while no such condition occurs with the steam purifier.

Cleveland, O. D. L. DARNELL.

Answering Mr. Gibbons

SPEAKING as a power plant engineer in commenting on Mr. Gibbons' letter in the July issue, I feel that my interests are bound up closely with those of my employer. The power plant man is not a highly paid executive and should he lose his job he very soon feels the pinch of poverty. The plant engineer and the outside consultant are not quite so dependent on the fortunes of one particular employer as are the actual operators who are closer to the line of economic stress.

I want my employer to turn out an article at a good competitive price so the returns will encourage him to remain in business and keep me in business also. Even the cost of one coil of packing, badly applied or wrongly chosen for the job, must be added to his unit cost and this small item, multiplied many times, may be just the lever that will raise his costs too high for competitive business.

I have worked under many plant engineers and am happy now under the direction of one of the best I have yet encountered but I contend that they are not fitted to practice the smaller economies which are the principal contributions to the suggestion box.

Plant engineers deal with matters and calculations far beyond the scope of the ordinary operating man. In that field they are rightly supreme. It is a mistake, however, to think slightingly of small economies such as:

Larger electric bulbs when a smaller will do.

Turning out unnecessary lights.

Using coil packing where rings are economical.

Wasteful cutting out of gaskets and scrapping of small, unused pieces.

Economy in the use of oil, grease, polish, wipe rags etc.

Installation of new parts and fittings of a type more suitable as borne out by the experience of the actual operator.

These are the type of suggestions that, over a period, show a saving and which the actual worker through close association with plant problems, the reading of engineering magazines and contact with other engineers, is competent to make

"Gate valves versus globe valves," the case I mentioned, would be laughable if it were not pitiable. The concern was so vast that it was literally teeming with consulting men.

My object was distinctly not monetary. I was quite satisfied with my position but I have had a wide experience and I had seen almost identical work done with globe valves. I put in extra time and labor to prove my point but the suggestion, even with proof, got nowhere. I never heard about it again and, after this lapse of time, I never want to.

Raking up an old globe valve and reconditioning it on my own time I installed it on one chiller and, for several weeks kept a close record of a batch of twelve. I was fortunate in securing the keen coöperation of the attendants who were interested (and, right here, I would like to say that it is a mistake to think that the workers in the lower brackets are not interested in betterment) and not once, during the month test period, did my globe valve fitted unit freeze up.

All the data was submitted through my chief but he told me that it was improbable I would hear further. He said that, in a large concern, there were too many hands for it to pass through who, for one reason or another, would quash it.

Passaic, N. J. MARK BELL.

"Simple Continuous Blowdown"

THE ARRANGEMENT of boiler blowdown control described by W. A. Lacey in the July issue is quite interesting and should undoubtedly improve conditions. Before the scheme is generally adopted, however, it would be well to consider some limitations which might affect the set-up in different localities.

In the first place very few boiler inspectors would permit any such hook-up as shown with only one valve indicated on the blowdown line, and even if double valved (which would seem to be a minimum precaution), the location of the continuous blowdown as shown always presents a possibility of draining the water from the boiler. For this reason it would seem better practice to locate the continuous blowdown takeoff from a higher point in the boiler—say just below the minimum water level.

Taking the continuous blowdown from the regular mud drum has the disadvantage, also, that the small continuous blow line may be easily clogged and jammed with mud or bits of scale. Another possible disadvantage is that frequently the feedwater is introduced in the bottom drum, which would mean that the continuous blowdown would be taking off less concentrated water than if located up nearer the steam liberating areas.

It might be better practice to divert the continuous blowdown stream through a separate small line to a heat exchanger, rather than introduce it into the regular blowoff lines, where it would interfere with the periodic check-up on the tightness of the regular blowdown valves.

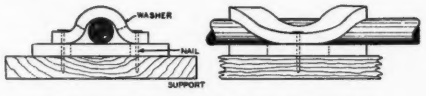
Philadelphia, Pa. W. A. SALLER.

Washers Substituted for Insulating Cleats

EMERGENCIES have a way of arising when one is least prepared to meet them. Often it is necessary to make repairs or replace parts of equipment, temporarily employing makeshift methods and materials. A substitute for insulating cleats, to use with any small wires, is the common, flat, round washers used for water-cocks which every engineer usually has on hand. Washers for cold-water taps or for cold-water globe valves are usually made of soft rubber.

Place one flat washer on the support, run a wire over it, then place another washer on top of the wire, and then fasten the assembled parts down on the support with two thin screw nails or two ordinary wire nails, the nails being used at each side so that no part of the nails touch the wire.

Such a simple substitute is safe, easy to use, and will often prove useful when the engineer has no insulating cleat on hand. The wire can be kept as high above the support as desired by using extra washers on the bottom.



Washers substituted for insulating cleats

A packing ring substitute follows: Take any fairly clean, hard or soft felt hat. Cut circles to fit fairly snugly around the stem and also the interior of the packing box. Such rings, lightly oiled, have done service in packing boxes of hot or cold water. Such felt can also be used for hot or cold water gaskets on pumps or unions. Of course such gaskets will not serve for high pressure steam or for hot engine cylinders.

Toronto, Ont. EDWARD JAMES.

Electrical Test Records

THE DAYS of haphazard records of electrical tests in power plants and substations are rapidly passing. Modern operation demands increasingly detailed and accurate information about equipment service under various conditions, and the engineer with a flair for systematic procedure is coming into his own. Testing is not merely a matter of reading meters and making computations; it involves a comprehensive knowl-

edge of the circumstances under which the test is made, and when properly carried out, leaves little indeed to the operator's memory.

Thus, in testing the condition of oil circuit breakers, the modern routine calls for thorough records as well as for carefully planned procedure. Complete identification of every breaker as to make, rating, location, particular bushing tested for insulating quality, the recording of weather conditions, personnel involved in the test, date, time, and any pertinent observed conditions are essential. Where such work is done on a service cycle or according to elapsed time, the making up of adequate forms is most important. If an outside testing organization does the work, the use of suitable forms by the operating company is just as important as where tests are self-conducted, so to speak. Coöperation between plant engineers and test consultants yields valuable results in fitting such forms to local conditions.

Since the object of all records is to save time and salvage data which might be lost through dependence on memory, it follows that the design of suitable records may be considered a major engineering interest. The ordinary "garden variety" of accountant is not qualified to prepare such forms but his suggestions may be worth much to the practical plant man. In too many cases in the past, records designed for testing use have lacked flexibility. Insufficient space has been assigned to the diary aspects of the job; too much clerical work has been expected of the operating force, and schematic diagrams have been overlooked as a means of quick and accurate identification of equipment units and parts. Trouble has been experienced in power plant and substation work where test forms have provided no suitable space or identification facilities for supplementary tests, as in the case where certain measurements had to be recorded with disconnecting switches closed and others followed with disconnects open. Attempts to save stationery have resulted in crowded readings and sometimes errors have crept into field data because of lack of system. All these exceptional conditions can easily be handled if sufficient study is given to records and forms, and new editions of test blanks can be brought out from time to time without impairing the value of the older work sheets, if the engineer recognizes the importance of the matter and acts accordingly.

Cambridge, Mass. H. S. KNOWLTON.

Blowdown

Q. You are probably aware of the vagueness about and the loose application of the term "gage" in connection with the change in height of water level shown in a boiler water column glass. For instance, in saying a boiler is being blown down 1½ gage per shift, I find that nearly every man has his own explanation as to what constitutes 1½ gage. What are your views on this subject?

B. F. K.

A. We agree that the term "gage" is loosely used and means little when considering the actual amount of water blown down, yet as a relative measure in a definite plant its usefulness does not depend upon an absolute value. If two gages blown down each shift today do not hold the concentration of the boiler water at the desired point, three gages blown down tomorrow may do so, provided the load and water conditions are similar. The Boiler Code says only that there must be at least three gage cocks, within the visible range of the gage glass, the lower one to be at least 2 in. above the lowest allowable water level, which varies with the type and construction of the boiler.

Our own interpretation of the term "gage" is that one gage is the distance between two of the gage cocks. For instance, with three gage cocks and water half way between the two upper ones, there is 1½ gages of water in the boiler. To blow down 1½ gages would allow the water to fall to such an extent that it would be on the level with the lowest gage cock. This might be 4, 6, 8 in. or some other distance depending upon the length of the gage glass and number of cocks used. The actual amount of water blown down would of course depend upon the drop in water level, diameter and number of drums, and the percentage of volume occupied by steam and water.

Another term sometimes used in this same way is the term "glass" indicating a blow down equal to the length of the gage glass. For instance, if three-quarters of a glass of water is being carried, this is blown down to the bottom, it would be equivalent to three-quarters of the glass. This term is of course open to the same objection as "gage."

Standardization of these terms might be of value in promoting a uniform engineering vocabulary in all sections of the country and we will leave the subject open for discussion by our readers. It must be remembered, however, that standardization of terms will do nothing toward a correct determination of the amount of blow down. Excessive blow down results in unnecessary heat loss and loss of feed water, while too little blow down may result in serious accidents or excessive maintenance due to carry-over. The determination of the correct amount of blow down is possibly only by the use of necessary instruments and this determination should be a part of the boiler or feed water treatment.

Refitting Metallic Ring Packing

Q. When metallic ring packing of the babbitted type starts to leak, is it economical to refit it?

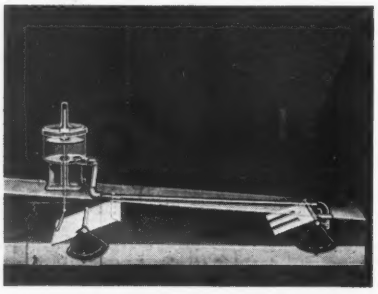
We have been informed by a packing manufacturer that it is impossible for any one to give a satisfactory answer to this question without having all the details including the size of packing rings and conditions under which they operate. Ordinarily refitting of metal packing rings, whether made from babbit, bronze or cast-iron, will prolong their usefulness.

FOR YEARS, the chief source of platinum has been the Ural mountains in Russia, but it now seems as though Canada takes first place in this field. Although lack of reliable figures from Russia makes it impossible to say definitely, it is believed that the bulk of the world's production of platinum metals (including platinum, palladium, ruthenium, rhodium, and iridium) comes as a by-product of the Canadian copper-nickel ores from the Sudbury, Ontario, district.

New Equipment

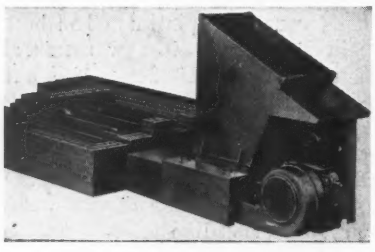
Iron Fireman Volumeter for Stokers

ONE OF THE major new developments reported by Iron Fireman Mfg. Co., Portland, Ore., and applicable to the company's various designs of automatic coal burners from the largest to the smallest sizes is an automatic air volume regulator, called the Iron Fireman Volumeter. This device regulates the amount, or volume, of air admitted to the combustion chamber with the coal. The volumeter is actuated entirely by applied principles of aerodynamics in such a manner that once set to supply the right amount of air for perfect combustion of any kind of coal, it will supply the right amount of air



for that coal, regardless of constantly varying conditions of the fire bed.

Developments have also been made in the "Poweram," formerly designated as CD, line of heavy duty stokers with more sizes added at the lighter end of the line. The Poweram is distinctive in that it represents a combination of the fuel distributing system employed within the combustion chamber by the conventional ram type of stokers with Iron Fireman's worm conveyor system of bringing the coal into the firebox. This type of stoker for power boilers and heating plants up to 300 hp. offers such advantages as a loose fuel bed, enabling air to reach all parts of the fire so that coal first cokes properly, and then the coke is broken up to insure clean combustion. With the Volumeter added to this machine to supply the correct proportion of air to fuel, it provides a heavy duty stoker offering a wide latitude in performance as to rate of combustion, quality of coal and adaptability to various types of boilers. Forced draft combustion air is supplied by a balanced rotor fan enclosed in a pressed steel housing.



An electric motor is used to drive the moving parts of the stoker and forced draft fan, the feed worm and ram being driven through speed change gears that run in a bath of oil at a constant speed for each setting, of which there are three. To take care of minor load changes, the off-and-on method of automatic regulation, actuated by steam pressure changes, is employed, for wider swings of load, however, the gears are shifted manually.

Prevention of fumes backing up into the hopper is accomplished by providing a small air intake placed in the fan casing at the point where the air leaves the fan with greatest velocity and connecting this intake to an air injector placed at the firebox end of the worm housing.

Airetool Tube Cleaners

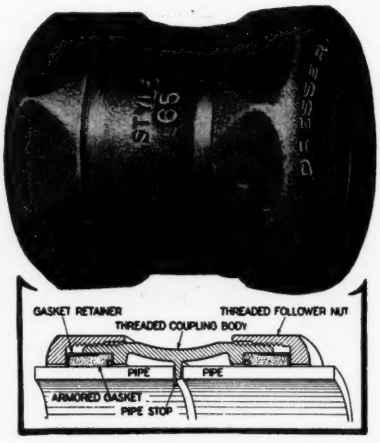
THE AIRETOOL MANUFACTURING Co. of Springfield, Ohio, has recently developed a line of tube cleaners for power plants which has many

new features, including the self-feeding cutter heads. This cutter head feeds into the tube as quickly as the scale is removed. The cleaner heads are of the expansion type with few wearing parts, and not only do they clean quickly and thoroughly but eliminate any possible injury to the tubes.

One feature of the motors, which makes for greater power and more efficiency, is the double exhaust which minimizes back pressure on the motor. Quite recently this company has developed exceedingly efficient tube cleaners for tubes as small as 5/8 in. inside diameter.

New Type Pipe Coupling

S. R. DRESSER Manufacturing Co. of Bradford, Penn., has recently announced the development of a new self-contained pipe joint, made in pipe sizes from 3/8 to 2 in. inclusive. Making the joint with



the Dresser Style 65 compression coupling simply involves inserting the pipe ends into the coupling, which comes assembled, and then tightening two threaded octagonal nuts.

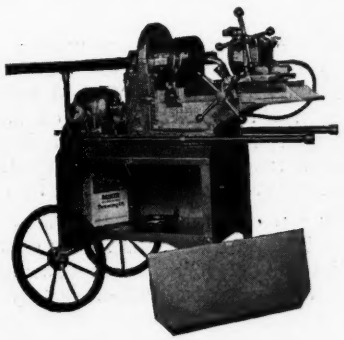
As the nuts are tightened, two resilient armored gaskets are compressed tightly around the pipe, gripping it and giving a positive seal. The resulting joint is reported to be not only permanently tight but to absorb normal vibration, expansion and contraction movements, and to permit deflections of the pipe in the joint.

Other advantages are these: the pipe need not be cut to exact lengths; joint making in cramped quarters is simplified; repairs on old lines can be quickly and easily made; and the joint is suitable for exposed lines because of its compact appearance.

L. H. GILMER Co., Tacony, Philadelphia, Pa., recently placed on the market a type of belt made both in V-type and Flat Kable Kord type, that is oil resistant. Mechanically, the belt has the same qualities as the regular Gilmer rubber-fabric type of belt. Materials used, however, are such that they are oil resisting and practically immune to the destructive action of oil.

Pipe Machine

BEAVER PIPE TOOLS, INC., Warren, Ohio, announce recent improvements in the Beaver Model A pipe machine made in sizes from ½ to 2 in. for capacities up to 12 in. pipe. All sizes are fully equipped with geared tools, driven by a 110 v. Universal reversing motor. Major improvements consist of the addition of a cone type reamer which quickly springs in and out of position, a thread and nipple

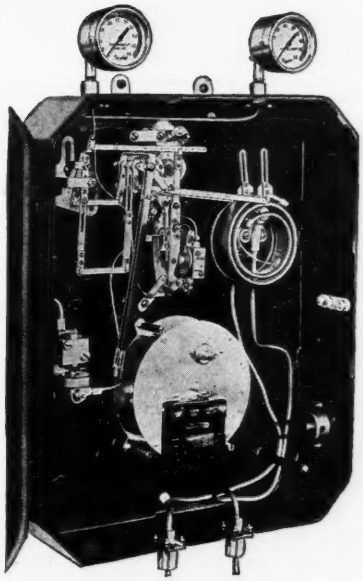


length gage conveniently located and visible even in poor light and, if desired, an enclosed stand. Machines are mounted on 17 in. wheels which are supplied in either steel or rubber tired as desired.

Taylor Reset Controller

TAYLOR RESET CONTROLLER, recently developed by the Taylor Instrument Companies, controls a temperature, pressure, rate of flow, or liquid level, in a predetermined relation to some other temperature, pressure, rate of flow, or liquid level. It can be used on all applications where a fixed differential must be maintained between two variables, one of which is under control; or where it is desirable to change the control point of a process in accordance with a predetermined ratio to a secondary process or condition.

This reset controller employs one complete Fulscope control system and, in addition, an extra tube system, pressure spring or manometer, depending on the application. The Fulscope mechanism and the second actuating or resetting mechanism are separate, yet so interconnected by linkage that any changes which occur in the resetting system are transferred to the Fulscope mechanism as control point adjustments. Both the adjusting and the controlled conditions are recorded.

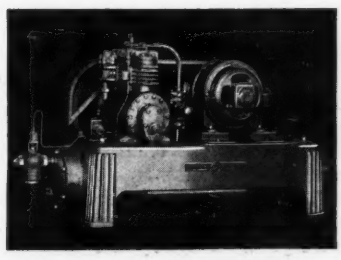


The adjustable linkage of this new controller permits control point changes in a great variety of ratios between controlling and resetting systems. The value of this ratio is always a constant for any one adjustment of the ratio linkage. The maximum ratio value obtainable with the reset controller is 5 to 1, which means that the control point can be shifted a maximum of 5 units for each unit change in the resetting system.

Control is maintained in the conventional manner by regulating the flow of air pressure to the diaphragm valve in the controlling medium line in response to changes in the apparatus under control. A constant 25 lb. per sq. in. air pressure is specified for the most efficient operation of the instrument.

New Condensing Units

EIGHT NEW CONDENSING UNITS of from 1½ to 20 hp. and rated at from 1.8 to 21.50 t. refrigerating capacity, have been announced by the Air Conditioning Department of the General Electric Co., Schenectady, N. Y. These new units are additions to the present G-E line; three of them, being equipped with water-cooled, double-tube counterflow condensers, and the others, having new shell-and-tube condenser-receivers.

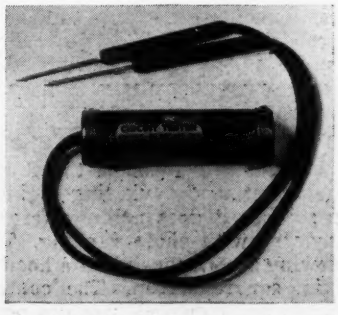


All of the new units have external motors with multiple V-belt drive to the compressors, liquid refrigerant filters, suction pressure controls, high-pressure safety lockouts, water regulating valves, service valves, and water and refrigerant connections. Units are shipped with a full charge of lubricating oil and a holding charge of Freon refrigerant. Included with each unit is a magnetic motor starting switch and a thermal overload protective device for the motor.

All of the new units are obtainable with several different motor and motor starter combinations, d.c. and a.c. to make them readily adaptable to the user's requirements. Standard and quiet motors are available; and two-speed motors can be had on condensing units of 5 hp. and larger which, together with manual or automatic control, provide greater operating efficiency where the cooling load varies widely.

Ajax Circuit Tester

THE AJAX CIRCUIT tester is a new device that has just been placed on the market by the Ajax Electric Shop, South Bend, Ind., for the use of electricians and maintenance men. It is used chiefly for quickly locating blown fuses on motor circuits and other power lines as well as the determination of the approximate voltage on live circuits. It consists of a lamp and resistor, a strong fiber case 4½ in. long and 1¼ in. in diameter to which are attached the two test leads. It weighs less than 6 oz., can readily be carried in the pocket and can be used on any 220 or 440 v. circuits, a.c. or d.c.



Ajax Circuit Tester

New Universal Oscillograph

A NEW INEXPENSIVE OSCILLOGRAPH with a variety of control panels, which are easily interchangeable so that the Oscillograph will exactly fit field or industrial and laboratory investigations and a wide selection of galvanometers for producing up to eight records, is announced by the Westinghouse Electric & Manufacturing Company. Among other features the new Type PA Universal Oscillograph offers 1, simultaneous viewing, the phenomena can be viewed while photographing; 2, daylight loading holder which can use 5, 10, or 200 ft. of 5 in. wide film or paper, and arranged so exposed portion can be cut off at any time desired without disturbing supply; 3, wide range of film speed by variable speed motor; 4, interchangeable galvanometers and vibrators and 5, automatic type ½ cycle starting time. The complete Oscillograph with controls exclusive of film-holder measures 25 in. long by 8½ in. wide by 9½ in. high and weighs approximately 50 lb.

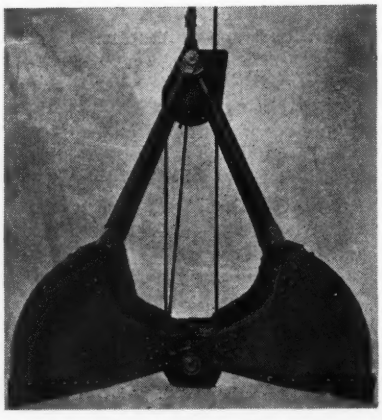
The Oscillograph is adapted for different applications, as it can be supplied with only the controls and galvanometers that are necessary for a particular requirement and then as the requirements change and grow, other controls and galvanometers can be installed in the original oscillograph. By the purchase of an inexpensive oscillograph and gradually adding new parts to the main case, as additional requirements demand it, a complete oscillograph is available at all times with the knowledge that unnecessary equipment has not been purchased. For example, the oscillograph consisting of the main case and controls can be purchased with two galvanometers and controls for these galvanometers so that either voltage or current values can be measured. Then as requirements grow and additional records are desired, galvanometers can be added for measuring additional current, voltage and watt values.

The main case has an upper, dust-tight optical compartment and the simultaneous viewing is built in so that it does not interfere in any way with photographing. The viewing screen consists of a hooded 5 in. square screen. The control panels are mounted in a compartment below the optical compartment and are easily removable. The industrial and laboratory types are supplied for either 6 v. d.c. or 110 v. a.c. or d.c.

Under automatic operation such as for fault recording on power systems, the starting time is 1/120 of a sec. This is obtained by means of a magnetic clutch and a continuous running motor. A floating arm in a loop of film makes it possible to use film or paper 200 ft. in length and still obtain this high starting time.

New Grab Bucket

DEVELOPED ESPECIALLY for rehandling materials, the new Type RH grab bucket recently put on the market by the Mead-Morrison Division of the Robins Conveying Belt Co., 15 Park Row, New York City, is reported to be exceptional in its relation of capacity to weight. The special shells are of an intermediate shape between flat and round, giving the advantages of the flat shell for digging and filling and of



the round shell for quick discharge. Its low height and extra width, combined with a low center of gravity, result in less head-room being needed in a vessel or car and give greater stability on a pile.

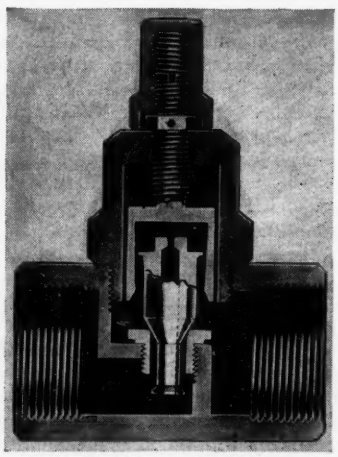
It has a rope reeving without reverse bends and a three-part purchase for rapid opening and closing. The top head is of structural steel with a manganese steel fairleader bolted in. The hinges are of cast steel of single and double ear construction with large bearings; and all bearings are provided with high-pressure lubrication. The links are of large diameter steel tubing welded to the cast steel ends, giving greater than usual strength with less weight and providing rounded surfaces which cause less damage to barges or cars than the usual rectangular sharp cornered link construction.

New Steam Trap

YARNALL-WARING Co., Chestnut Hill, Philadelphia, Pa., announce a unique steam trap, radically new in appearance, in adaptability and in operating principle. This trap, known as the Yarway Impulse Steam Trap, is made in six sizes, ½ to 2 in. with a capacity range from 475 to 9950 lb. per hr. It is little larger than a pipe union; the ½-in. size weighing only 1⅛ lb. The body is made of cold rolled steel, the working parts of hard monel, bonnet and cap of brass. Each trap is factory-set to operate all pressures from 0 to 400 lb. per sq. in.

This trap depends for its operation on the difference in flow characteristics of cold water, hot water and live steam, flowing through two orifices with a chamber between. There is only one moving part, the valve disc itself, shown in section view. Movement of this valve disc is governed by variations in pressure in the space above valve piston called the control chamber. These changes in pressure occurring with changes in temperature of condensate ranging from cold water to water at steam temperature.

When handling cold water, the pressure under valve piston (inlet side of trap) is greater than the reduced pressure in control chamber above piston—clearance between piston and cylinder acting



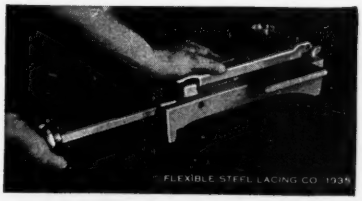
as first orifice—and valve opens to allow free discharge of condensate. As the accumulation of cold condensate disappears the remaining

condensate approaches steam temperature, flashing takes place in control orifice in center of valve disc, the flow is choked and the pressure in control chamber builds up to close valve. Valve disc, piston and center orifice are accurately proportioned to give positive opening of valve when cold condensate collects and quick closing when pipe system is hot and there is no condensate or the condensate is at or near steam temperature.

The manufacturers state that the merits of this design have been conclusively proved by exhaustive tests in the Yarway Steam Laboratory and by two years of actual service under a wide variety of conditions in leading industrial plants.

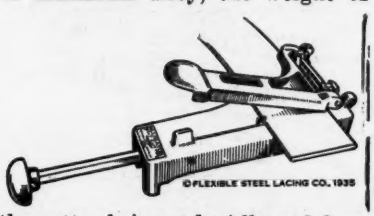
Alligator Belt Cutter

AN 8-INCH FLAT belt cutting tool which employs a new principle in mechanical belt cutting, is announced by the Flexible Steel Lacing Co., 4607-31 Lexington Street, Chicago. The cut is made by pushing the knife through the belt from one edge to the other. The knife is mounted on a plunger in a slot, as illustrated, and is operated by a direct arm push without mechanical leverage.



The knife, it is claimed, cuts easily through most belting, and will cut even the thickest and toughest belts up to 8 in. in width with little effort. The knife, of special alloy steel, will make several thousand cuts and is easily replaceable.

The belt is held immovable by the equalizing clamp or held down while the cut is being made. The clamp is also a guard for the blade. Clamp and frame are strongly built of aluminum alloy, the weight of



the cutter being only 4 lb. and 3 oz. The cutter is used either on the bench, as illustrated, or is up-ended on the floor, if desired.

Arthur D. Little Dies in Maine

ARTHUR DEHON LITTLE, noted chemical engineer and president of Arthur D. Little, Inc., Cambridge, Mass., died suddenly while on his vacation on August 1 at Northeast Harbor, Maine. His widow, the former Miss Henrietta Rogers Anthony of Boston, whom he married in 1901, was with him at the time of his death.

Arthur D. Little was one of America's brilliant chemists and the laboratory of which he was the head made many outstanding contributions in the field on science and industry. A graduate of Massachusetts Institute of Technology in 1885, Mr. Little received many scientific honors during his life time. Four years ago he was awarded an honorary degree at Columbia University and during the same year received the Perkins Medal in recognition of his contributions to industrial chemistry.

Shortly after his graduation from M. I. T. he was appointed superintendent of the first mill in the United States to make sulphite wood pulp. Later he started practicing chemical engineering in Boston and in 1909 founded the firm which bears his name. The reception room of the Arthur D. Little laboratory is a veritable museum of industrial research trophies. It is filled with interesting exhibits of materials produced and methods which speak more eloquently than words of the skill and accomplishments of the staff of scientists which he directed. In this room there is the famous silk purse made from a sow's ear, Mr. Little's answer to a challenge of a friend. Of no practical value in itself, this feat nevertheless demonstrated the power of chemistry. From the glue which he extracted from the ears of sows, Mr. Little made a silk fibre which was woven into a silk purse with the aid of a small hand loom.

Mr. Little was a fellow of the American Academy of Arts and Sciences, the Chemical Society of England and the Institute of Fuel of London. He served as president of the American Chemical Society, the Institute of Chemical Engineers and the Society of Chemical Industry of London. He was interested in the activities and administration of the Massachusetts Institute of Technology during his entire lifetime. He was a life member of the M. I. T. Corporation, and served on its visiting committees for the departments of chemistry and chemical engineering. In initiating the school of chemical engineering practice at M. I. T. and in securing for it the financial support of the late George Eastman, he made an outstanding contribution to engineering education, recognized the world over. Mr. Little was the author of numerous scientific works on industrial chemistry published in scientific journals.

Illuminating Engineers to meet in Cincinnati September 3-6

THE ILLUMINATING ENGINEERING SOCIETY will hold its 29th Annual Convention at the Netherland-Plaza Hotel in Cincinnati, September 3 to 6. As has been the practice in the past, there will also be held a lighting equipment exposition. This year the exposition will be on a very much larger scale than ever before—not only will the large halls of the hotel be filled with the latest types of equipment but there will be outdoor displays on a wide scale.

The technical program that has been arranged, features many papers covering a wide variety of illuminating interests. The first day, September 3, will be devoted entirely to the National Lighting Sales conference.

Among the papers to be presented the following are of particular interest. "The Present Status of Photometry," by W. E. Forsythe, Lamp Development Laboratory, General Electric Co.; "Comfortable High-Level Illumination," by A. B. Oday and Walter Sturrock, engineering department, General Electric Co.; "A Practical Approach to Inspection Lighting Problems," Richard G. Slauer, Department of Applied Lighting, Westinghouse Lamp Co.; "Applications of Sodium Vapor and High Intensity Mercury Vapor Lamps," O. P. Cleaver, Commercial Engineering Dept., Westinghouse Lamp Co.; "Quality of Lighting," by M. Luckiesh and F. K. Moss of the Lighting Research Laboratory of the General Electric Co.

Of particular interest to those concerned with European lighting developments will be the session on Friday afternoon, September 6, Echoes from the Ninth Meeting of the International Commission on Illumination held in Berlin and Karlsruhe, July, 1935. The American delegates will review the high lights of the session and present significant developments in European lighting.

News From the Field

APPROPRIATION of $75,000 has been voted by the U. S. House of Representatives to defray the expenses of foreign delegates to the Third World Power Conference. The resolution passed authorizes the President to invite representatives of 45 nations to attend the conference to be held in the United States in 1936.

STEAM EQUIPMENT MFG. CO., Jenkins Arcade Building, Pittsburgh, Pa., has been appointed distributor in the Pittsburgh area for The Ashton Valve Co.

TWO OF THE WORLD'S largest hydrogen-cooled synchronous condensers will be built by the General Electric Company for the Bureau of Power and Light, City of Los Angeles, to be installed on the receiving end of the 270-mile transmission line from Boulder Dam. These new hydrogen-cooled machines will be rated at 60,000 kva., 13,800 v., 60 cycles.

The installation will be an example of one of the standard applications for synchronous condensers where they perform the function of controlling the power factor of the load so that regulation and losses of the line can be held within reasonable values—thereby controlling within limits the voltage of the receiving bus.

THE ASHTON VALVE CO., Boston, Mass., has appointed The Ashmead Danks Co., Rockefeller Bldg., Cleveland, Ohio, distributor in the Northern Ohio area for Ashton products.

THE LACLEDE STOKER CO. announces the appointment of J. H. Collier as their representative in the Chicago territory. Location of the office is 417 South Dearborn St.

A. M. BYERS CO., Pittsburgh, Pa., announces as a third major expansion project, that, in addition to its wrought iron mill at Ambridge and the making of all kinds of wrought-iron products, it will manufacture Byers steel pipe under the same supervision as its wrought-iron pipe. The wrought-iron pipe will be made for corrosive services with steel pipe for other piping requirements, thus meeting all needs of the company's customers.

INSTRUMENT REBUILDERS AND REPAIR CO., 611 Adams St., Hoboken, N. J., has entered into the business of taking obsolete, broken, discarded or inaccurate instruments and completely rehabilitating them superior to what they were when new and at a cost much below new instruments.

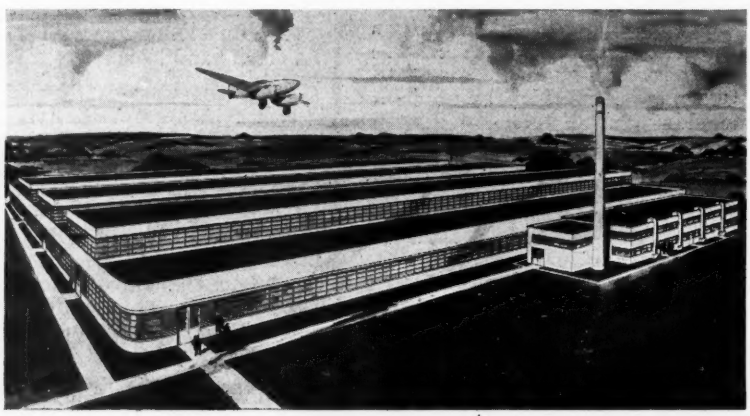
HAGAN CORP., Pittsburgh, Pa., through its president, J. M. Hopwood, has announced the appointment of Dr. Everett P. Partridge as director of research of Hall Laboratories, Inc. In this position, which he will assume on September 1, Dr. Partridge will be associated with Dr. Ralph E. Hall, the managing director of Hall Laboratories and his staff, with the scientific and technical specialists of Hagan Corp., the Buromin Co., and Calgon, Inc., all of which are allied organizations, and also with the incumbents of the Industrial Fellowship on Calgonizing sustained by Calgon, Inc., at Mellon Institute of Industrial Research. Dr. Partridge has distinguished himself during the past 10 yr. by his researches on boiler-water problems. Since 1933 Dr. Partridge has conducted active research on boiler-water problems as a result of a movement initiated by Hall Laboratories and later taken up by the Joint Research Committee for Boiler Feedwater Studies, as a coöperative investigation by the American Society of Mechanical Engineers and the U. S. Bureau of Mines. This investigation is proceeding at the present time. As director of research of Hall Laboratories, Dr. Partridge will continue his interest in boiler-water treatment and in the processing of water for general industrial use.

AT THE SEVENTEENTH National Metal Congress and Exposition, Harry W. McQuaid of Republic Steel Corp. will present the Edward De Mille Campbell lecture on the subject of Grain Size and Control in Steel. This will embody the results of research extending over 16 yr. with such firms as Timken Roller Bearing Co., Timken-Detroit Axle Co., Precision Gear Blank Co., and Republic Steel Corp. The lecture will be delivered at the annual meeting of American Society for Metals in Cleveland, O., on Oct. 2nd.

ON AUGUST 20 the Kansas Utilities Co. filed suit in the United States Supreme Court challenging the right of the federal government, through the Public Works Administration, to donate funds to cities to aid in the construction of municipal power plants to compete with privately owned power companies. This is the first case of its kind to reach the Supreme Court. It is expected this case will be taken up after the court resumes its session in October. The utility company contends that a municipality has no lawful right to enter into a coöperative enterprise with the federal government whereby loans and outright grants of money are furnished the municipality for the purpose of constructing a municipal power plant to compete with a privately owned plant. This action, it is claimed, would result in the confiscation of the utility's property without due process of law and in violation of rights guaranteed by the federal constitution.

HARRY S. BROWN was elected President of the Foster Wheeler Corp. at a meeting of the board of directors held July 22. Mr. Brown joined the Power Specialty Co. in 1904, after graduation from Cornell University. He served in its engineering and sales departments for 15 yr., becoming manager of the New England Division with headquarters at Boston. In 1919 he accepted the position of Vice President of Wheeler Condenser and Engineering Co. which in 1927 consolidated with the Power Specialty Co. to form Foster Wheeler Corporation and Mr. Brown became its Vice President in charge of sales and a director. Mr. Brown now succeeds his brother, J. J. Brown, as President. J. J. Brown had held both the offices of Chairman of the Board and President for the past 2 yr. He resigned as President but continues actively as Chairman of the Board. At the same meeting David McCulloch, formerly Secretary and General Manager, was elected Executive Vice President and Walter F. Keenan, Jr., George B. Ferrier and J. J. Nelis were elected Vice Presidents. P. N. Wenz was elected Secretary.

FOSTER WHEELER CORP. announces that it has recently granted a license to the Green Fuel Economizer Co., Inc., of Beacon, N. Y., to manufacture an extended surface economizer under Bell patent 1,565,305. E. Green & Son, Limited, of Wakefield, England, the associated company of The Green Fuel Economizer Co., Inc., acquired the European rights to the Foster economizer several years ago.



AT SPEEDWAY, Indianapolis, Ind., The Austin Co. of Cleveland, O., are constructing this new plant for the Allison Engineering Co., a division of the General Motors Corp. The new plant is of modern design, with welded steel construction and horizontal window areas completely encircling the building. It will occupy a space of 13½ acres and will be used for the production of 1000 hp. liquid cooled aircraft engines. The design of the plant is such that air conditioning equipment may be added at a later date.

CONTRACTS, FOR RAILWAY EQUIPMENT, in excess of $2,000,000 have been awarded to the Westinghouse Electric & Manufacturing Company for the Board of Transportation of New York City.

The Westinghouse award is for motive power, control units and other accessories to be installed on new subway cars ordered for service on city-operated lines in New York. The equipment will be placed on cars built by the American Car & Foundry Co., the Pullman-Standard Car Manufacturing Company, and the Pressed Steel Car Company. Five hundred new cars have been ordered from these builders to increase existing equipment and to extend service on the Eighth Avenue and connecting subway lines. The contract for new cars exclusive of electrical equipment is the largest order placed for railway equipment since 1931.

Power generating equipment, including mercury arc rectifiers, purchased from Westinghouse recently, will furnish power for these new cars.

VISITORS TO the Machine Tool Exposition, to be held in Cleveland, Ohio, Sept. 11 to 21 will be able to see in Booth E-310 of The Lincoln Electric Co. demonstration of the Shield Arc Welder on light gage sheet metals and on heavy plate, also the use of various electrodes for making new tools and refacing old ones, and of accessories for protection of operators.

THE GALE ENGINEERING CO., 136 Liberty St., New York City, has been appointed as the representative for the Combustion Control Division of A. W. Cash Co. George W. Gale has been identified with combustion control work in New York City and the surrounding territory for several years, and was until just recently associated with the L. J. Wing Manufacturing Co.

For the Engineer's Library

BULLETIN No. 37R, issued recently by Taylor Instrument Cos., Rochester, N. Y., deals with the Taylor "Dubl-Response" control system and was prepared to be of assistance to engineers confronted with problems of maintaining precision control of temperature, pressure, rate of flow or liquid level on continuous processes which involve time lags and load changes.

AGGLUTINATING VALUES of some of the lower volatile Virginia coals is discussed in Bulletin No. 20 of the Engineering Experiment Series published by the Virginia Polytechnic Institute, Blacksburg, Va. This bulletin is the result of laboratory work by F. H. Fish, research professor of chemical engineering, who comes to the conclusion that tests of agglutinating value may serve as a means of classifying some coals which would be improperly classified by the fuel ratio method.

How WINTON ENGINES are meeting the diversified needs for railroad, industrial and marine power is shown pictorially in a recent bulletin, Winton Power, published by the Winton Engine Corp., Cleveland, Ohio.

ARMOUR INSTITUTE OF TECHNOLOGY, Chicago, Ill., recently published a report of their committee on Shop Policy. This booklet gives results of an investigation of the subject of shop work in engineering colleges and recommended that the Institute continue shop courses in the case of students in the mechanical, electrical, chemical, fire protection engineering, and be offered as electives for students in civil engineering and engineering science. Copies of the report may be obtained from the Institute, Chicago, Ill.

FOLDER FROM Graver Tank & Mfg. Co., Inc., East Chicago, Ind., shows the kinds of tanks and steel plate construction fabricated by the company and gives a list of products of steel, alloy steels and aluminum.

AMERICAN METER CO., 60 E. 42nd St., New York City, has recently published its Bulletin AG-2 which completes a new series of six apparatus bulletins, AG-1 to AG-6 inclusive, now available in the loose leaf 8½ by 11 in. standard size. The literature is revised, up to date, describing and illustrating the following products: AG-1 Meter Provers, AG-2 American Calorimeter, Sulphur and Ammonia Test, Hydrogen Sulphide Test, Specific Gravity Apparatus; AG-3 Wet and Dry Test Meters; AG-4 Recording and Indicating Demand Meters; AG-5 Protector Siphon Gages, Single Tube Pressure Gages and High Pressure Differential Gages; and AG-6 Service Cleaners.

A NEW EDITION of the "Pocket Manual of 'Megger' Practice" has just been published by James G. Biddle Co., 1211 Arch Street, Philadelphia, Pa. This manual which measures 4¼ by 7¾ and contains 128 pages is devoted to a discussion of electrical insulation and its maintenance, particularly as it concerns the use of the "Megger" instruments. It is a booklet which should be of interest to those who are responsible for the installation, care and maintenance of all types of electrical apparatus. "Megger" is a registered trade mark, coined some 30 yr. ago from the words "MEG ohm test ER" meaning a device for testing or measuring megohms. The instruments known by this name have a wide range of application and to a certain extent the term has become synonymous with the measurement of insulation resistance. The new manual does not render obsolete the previous editions bearing a similar title (dating back as far as 1923). It is intended to amplify the subject of insulation testing in a manner that should be appreciated by those having to do with that fundamental factor in electrical equipment.

There is a price of 25 cents on the booklet but it will be sent to responsible persons without charge.

UNITED CONVEYOR CORP., Old Colony Bldg., Chicago, in an attractive bulletin entitled Cinder Reclaiming, Fly Ash Disposal, Boiler House Sweeping Systems, describes these newly developed products, giving in detail their features of construction and arrangements for installation in power plants.

NATIONAL ALUMINATE CORP., 6216 W. 66th Place, Chicago, Ill., is distributing a circular describing Nalco Colorimetric Testing Kits, one for oxygen and another for silica and sulphate. These kits have just recently been made available to customers.

YARWAY FORGED STEEL Blowoff Valves is the title of a folder being distributed by Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa., describing and illustrating the various designs manufactured by the company for working pressures from 600 to 1500 lb.

COMBUSTION CONTROL SYSTEMS of the air operated type as made by the Bailey Meter Co. of Cleveland, Ohio, is described in detail in Bulletin No. 102. Advantages of automatic combustion control, fundamental principles, details of the equipment, diagrammatic drawings and photographs of actual installations are included.

ALLIS-CHALMERS MANUFACTURING CO., Milwaukee, Wis., has recently issued its leaflet 2202 describing and illustrating the Synchro-Operator" for automatically paralleling a.c. generators.

TEMPLETON, KENLY & CO., 1020 S. Central Ave., Chicago, gives engineering data on Simplex adjustable tank supporting jacks in a recently published bulletin designated as No. 835.

POWELL BRONZE valves for use with The Mueller Brass Co.'s streamline copper pipe is made the subject of a bulletin recently issued by The Wm. Powell Co., 2525 Spring Grove Ave., Cincinnati, Ohio. These valves can readily be soldered to the tubing and are known as streamline or soldered joint end valves. The bulletin describes in detail globe, rising and nonrising stem gate valves, also check valves.

TO DIFFERENTIATE the Hele-Shaw pump from a legion of pumps with which it has little in common, the term Hele-Shaw Fluid Power was created by the American Engineering Co. of Philadelphia in preparing a new catalog for Hele-Shaw pumps, motors and transmissions. In this catalog, the resemblance of Fluid Power to electric power is carefully drawn. It dawns on one that the use of Fluid Power is not restricted to hydraulic presses but is capable of spreading to a host of new applications in need of a flexible, controllable source of energy. The Hele-Shaw catalog contains many illustrations, charts, tables, drawings and engineering data indicating the construction, operation, application and specifications of Hele-Shaw pumps, motors, transmissions, regulators, pumping units, differential valves and pipe testing machines.

INDUSTRIAL THERMOMETERS are listed in Catalog No. 1125 just issued by the C. J. Tagliabue Mfg. Co., of Brooklyn, N. Y. The catalog contains 24 pages of information on industrial thermometers, miscellaneous metal and woodback thermometers, hygrometers, U gages, mercurial vacuum gages and mercurial barometers.

SURFACE CONDENSERS of welded sheet shell construction as made by the Worthington Pump & Machinery Corp., Harrison, N. Y., are shown in a recent bulletin, W-200-B2A; Snow pot valve steam pumps, Type PC, for handling liquids at pressures up to 800 lb. per square inch as made by the same company are covered in another bulletin, W-103-B1; air lift pumping systems by L-800-B1 and vertical centrifugals by W-317-B4.

FACTS ABOUT 7284 industrial plants in eight states are given in a 19-p. booklet issued by Appalachian Coals, Inc., Transportation Bldg., Cincinnati, Ohio.

THE MEDART CO., St. Louis, Mo., is sending out a 143-p. catalog, fully indexed and illustrated of power transmission equipment.

Power Plant Construction News

Ark., Crossett—Crossett Lumber Co., Crossett, plans installation of electric power equipment in proposed new local pulp and paper mill for kraft paper production. Plant will consist of several units and will cost about $4,000,000. Financing in that sum has been arranged through RFC.

Ark., Luxora—Common Council, has plans under way for new municipal electric light and power plant. Application has been made for Federal aid in sum of $78,100 for project. Proposed to ask bids in near future. Moody & Co., National Standard Building, Little Rock, Ark., are consulting engineers.

B. C., Prince Rupert—Mutual Pulp & Paper Mills, Ltd., Prince Rupert, recently organized, care of F. L. Buckley, 1030 Hamilton Street, Vancouver, B. C., representative, plans installation of electric power equipment for mill service, and electric power substation, at proposed new pulp and paper mill at Prince Rupert. Entire project will cost about $5,000,000. Main power supply will be secured from the Northern British Columbia Power Co.

Calif., Los Angeles — Metropolitan Water District, 306 West Third Street, will receive bids until Dec. 3 for centrifugal pumping units and accessories for main pumping plants of Colorado River Aqueduct Project (Specification No. 116).

Calif., Los Angeles—North American Aviation, 1775 Broadway, New York, N. Y., plans installation of electric power equipment in new aircraft manufacturing plant at Mines Field, Los Angeles, where 20-acre tract of land has been acquired. Cost about $500,000 L. B. Norman, 1034 Seventeenth Street, Santa Monica, Calif., is consulting engineer.

Calif., South San Francisco—E. I. du Pont de Nemours & Co., 601 Third Street, San Francisco, with headquarters in duPont Building, Wilmington, Del., plans installation of electric power equipment in new paint and varnish works on Linden Avenue, South San Francisco. Cost about $175,000, with machinery. Company engineering department is in charge.

Conn., New Britain—Landers, Frary & Clark, 47 Center Street, manufacturer of electrical appliances, etc., plan installation of electric power equipment in new six-story addition, 60x300 ft., to be used for electric refrigerator manufacture. Cost about $100,000. W. F. Brooks, Lewis and Gold Streets, Hartford, Conn., is architect.

D. C., Washington—Columbia Specialty Paper Box Co., 228 First Street, N. W., plans installation of electric power equipment in new four-story plant addition. Cost over $75,000, with machinery. A building permit has been issued. A. J. Scullen, 1224 Lawrence Street, N E., is consulting engineer.

Fla., Miami—Wagner Brewing Co., Sixth Avenue and N. W. Fourteenth Street, plans installation of power equipment in new addition to brewing plant. Cost close to $40,000.

Fla., Tampa—American Can Co., 230 Park Avenue, New York, N. Y., plans installation of electric power equipment in new multi-unit plant on 20-acre tract of land on First Avenue, Tampa, recently acquired. Cost about $275,000. Company engineering department is in charge.

Ill., Granite City—Granite City Steel Co., plans installation of electric power equipment in connection with new mill additions for strip steel production. Cost over $4,000,000.

Ill., Waukegan—Johns-Manville, Inc., manufacturer of insulation and building products, plans installation of electric power equipment in new additions to plant at Waukegan. Cost close to $100,000. Company headquarters are at 22 East Fortieth Street, New York, N. Y.

Ind., Fort Wayne — International Harvester Co., 606 South Michigan Avenue, Chicago, Ill., plans installation of electric power equipment in three new one and two-story additions to motor truck plant at Fort Wayne. Entire project will cost over $600,000. Company engineering department is in charge.

Ind., Indianapolis—Allison Engineering Co., Speedway, manufacturer of aircraft engines, parts, etc., plans installation of electric power equipment in four new one-story plant additions. A one-story power house, 32x32 ft., is included in project, which will cost over $400,000. N. H. Gilman is president and general manager; company is a subsidiary of General Motors Corporation, New York, N. Y.

Iowa, Muscatine—City Council is considering a municipal hydroelectric power development on Cedar River, including power dam, artificial lake about 11 miles long, generating station and transmission line to city. Proposed to arrange special election to approve project at early date. Estimated cost $3,500,000. Financing will be arranged through Federal aid.

Kan., Strong City—City Council is planning new municipal electric light and power plant, using Diesel engine-generator unit. Cost about $53,000. Financing will be arranged through Federal aid. E. T. Archer & Co., New England Building, Kansas City, Mo., are consulting engineers.

La., Alexandria—City Council plans extensions and improvements in municipal electric light and power plant, including installation of new equipment. Cost about $200,000. Financing is being arranged through Federal aid.

Md., Baltimore—Aluminum Trailer Mfg. Co., South Kresson Street, plans installation of electric power equipment in new one-story plant addition, 100x250 ft. Cost over $100,000. Edward St. John is president.

Michigan, St. Louis—Michigan Alkali & Chemical Corporation plans installation of electric power equipment in new two-story plant. Cost over $150,000, including machinery.

Neb., Alliance—Common Council has plans under way for extensions and improvements in municipal electric light and power plant, including installation of new equipment. Estimates of cost are being made. Burns & McDonnell Engineering Co., 107 West Linwood Boulevard, Kansas City, Mo., is consulting engineer.

N. Y., Valatie—Village Council plans early construction of a new municipal electric light and power plant. A fund of $109,000 has been arranged through Federal aid for new station, a small portion of appropriation to be used for erection of a municipal warehouse building.

N. C., Murphy — Tennessee Valley Authority, Knoxville, Tenn., has selected site on Hiwassee River, about 20 miles from Murphy, for proposed new hydroelectric power and flood control development. Power dam will be about 275 ft. high and over 1000 ft. long. Project will include generating station, power substations and switching stations, transmission and distributing lines. A fund of $13,000,000 is being arranged. J. D. Bragg is chief of unit of engineering service division in charge.

Ohio, Akron—Enterprise Mfg. Co., Ash Street, plans installation of electric power equipment in new three-story addition to hardware factory. Cost close to $50,000.

Ohio, Greenfield—Board of Public Affairs has plans under way for extensions and improvements in municipal electric light and power plant, including installation of new equipment. Cost about $25,000. W. I. Barrows, Reibold Building, Dayton, Ohio, is consulting engineer.

Ohio, Jackson—Ohio Quartz Products Co., Main Street, plans installation of electric power equipment in connection with rebuilding of mill, recently damaged by fire. Loss estimated over $50,000.

Ohio, Springfield—Central Brass & Fixture Co., manufactuer of automobile bumpers, etc., a subsidiary of Electric Auto-Lite Co., Champlain Street, Toledo, Ohio, plans installation of electric power equipment in connection with expansion in plant to double present capacity. Cost about $150,000.

Pa., Homestead—Carnegie Steel Co., Carnegie Building, Pittsburgh, Pa., plans installation of electric power equipment in new plate mill at Homestead works. Entire project will cost over $5,000,000. Company engineering department is in charge. Company is a subsidiary of the the United States Steel Corporation, New York, N. Y.

Pa., Oakmont—Universal Lubricating Co., Allegheny Avenue, plans installation of electric power equipment in connection with proposed rebuilding of grease-manufacturing plant, recently destroyed by fire. Loss over $45,000.

S. D., Armour—Northwestern Public Service Co., Huron, S. D., is considering new power plant at Armour, including power substation facilities and distributing lines. Cost about $100,000. Company has asked for a 20-year franchise for light and power service, agreeing to build plant noted if granted. Special election has been called to approve proposed franchise.

S. D., Sioux Falls—City Council plans extensions and improvements in municipal electric light and power plant, including installation of new 3000 hp. generating unit and accessory equipment. Cost about $175,000. R. E. Bragstad is city engineer, in charge.

Tenn., Knoxville—Knoxville Heating & Cooling Co., Inc., plans new steam power plant for central heating service in business district, with adjoining plant for central cooling system for air-conditioning in same area. Site has been selected on the Tennessee River. Cost over $450,000. Financing will be arranged through Federal aid. Harold A. Lynette is vice-president, in charge.

Va., Shipman—Inland Service Corporation, Charlotteville, Va., plans new addition to cold storage and refrigeration plant at Shipman. Cost close to $100,000, with machinery. J. M. Rothwell is president.